CHEMISTRY

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A SCIENCE SERVICE PUBLICATION

Against Friction

➤ MAKING SMOOTH the rough places of the world would seem as idealistic a goal as one could seek. Although the lubrication engineers might not recognize their work described in such terms, theirs is an important role in keeping the wheels of industry turning harmoniously. As is apparent in this month's lead story, the requirements of lubrication have come a long way since a bit of animal fat or vegetable oil on a greasy rag was daubed on to stop squeaks.

From bear's grease to modern hydrocarbon lubricants is not a long journey in time, but it represents a very long stride in our understanding of the chemical and physical properties which make the difference between a good lubricant and one which, in one way or another, fails to accomplish its purpose. Mapping the areas covered by the various ingredients which make up a given type of lubricant, and the modifications which result from the various additives, is a job in applied research typical of many offered by industry to chemistry students at the present time.

Beyond the field of application of today's materials, the race between design of engine and lubricant is like many another modern counterpart of the evolution of claw and shell. Engines tend to grow constantly lighter, smaller, swifter and more powerful. Such development demands stronger and tougher metals with higher melting points and less tendency to flow and warp when running hot. Such engines create constantly more acute lubrication problems, and oils and greases must take on new characteristics to meet their needs. Here is another field in which chemists are needed.

Meanwhile other chemists have been busy making substitutions in the molecules of well-known compounds, for they have found that one atom substituted for another will often make startling changes in the properties of the material being studied. An atom of fluorine in a hydrocarbon molecule, for example, may send the freezing point down to an unexpected low. An atom of silicon strategically placed may also alter the properties of a hydrocarbon oil to adapt it for use at extreme temperatures. Other unfamiliar elements may hold possibilities for different modifications of common materials. The opportunities for chemical discoveries are immediate, vast and exciting.

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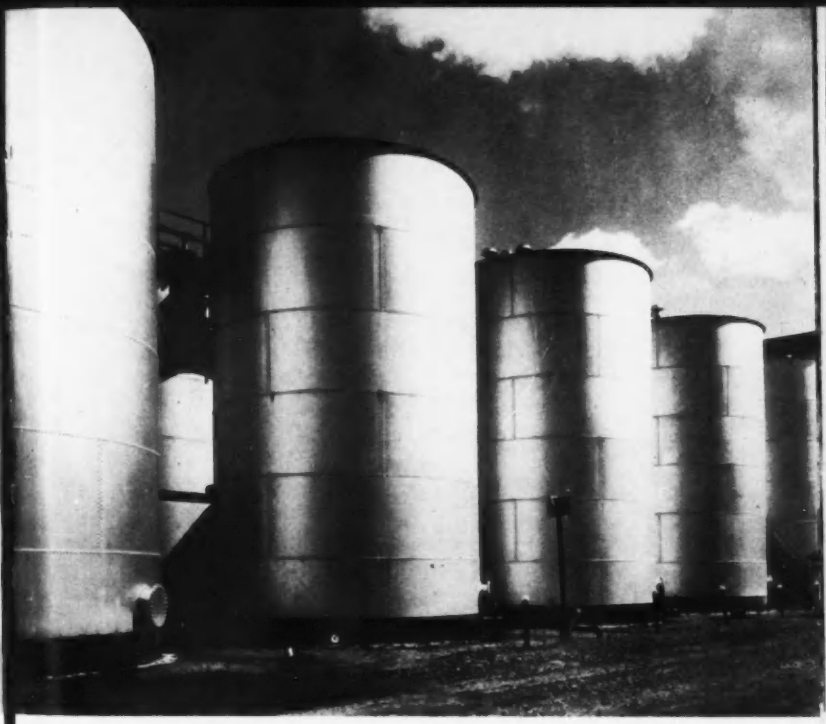

▶ STORAGE TANKS *hold oils ready to be saponified and mixed to make modern lubricants. Choice of several ingredients lets greases be modified according to use.*

Development of a New Grease

by GORDON BRIGHT
Technical and Research Division, The Texas Company, Port Arthur, Texas.

▶ MANY YEARS ago, the lubrication of industrial machinery and transportation equipment was a simple matter. Motive power was furnished by water or air, by mules or horses, or by man.

All types of equipment were slow in motion, machining methods were crude and simple, and bearings were rough and loose fitting. Occasional application of lard oil or tallow sufficed to maintain the slow pace of the premechanized era.

The transition from low speed to high speed, from crudity to precision, from the spasmodic and ineffectual hand lubrication of moving parts with tallow to the application of highly specialized greases by automatic lubri-

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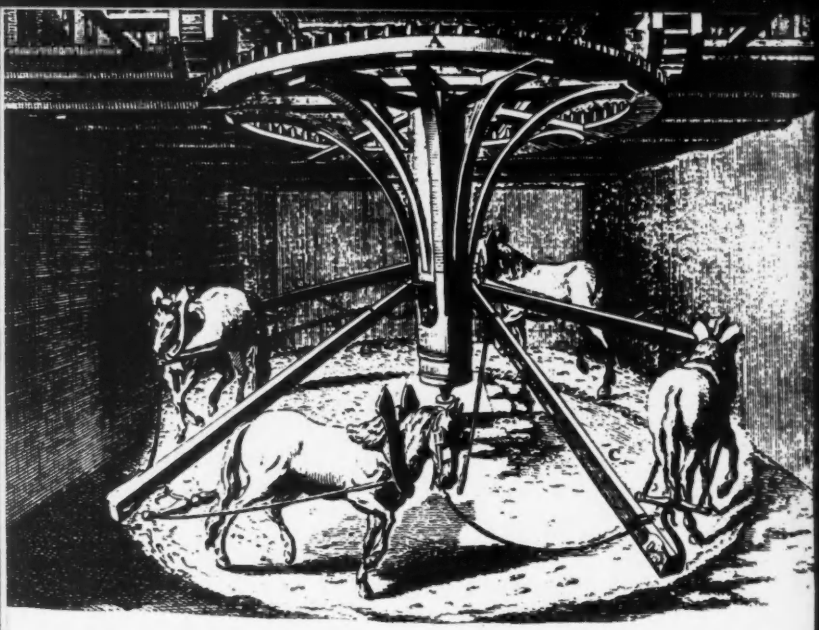
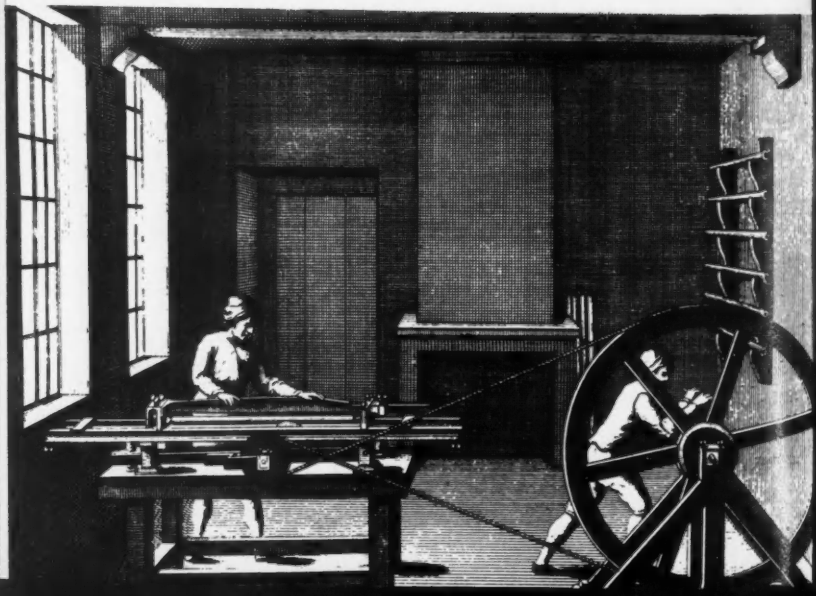


➤ LUBRICATION *was less of a problem when machinery ran at these speeds and with this kind of power.*



▸ WATER-RESISTANT *lubricants would seem of prime importance to machinery working in conditions like this.*

—Courtesy of Allis-Chalmers Mfg. Co.

cators came very gradually at first. But in recent years progress in these fields has advanced at an ever increasing rate. During the early days of the current century and before, lubricants were developed only as products for general application. Today the petroleum industry tailors lubricants to fit the many special needs which arise in the course of mechanical development.

To keep pace with the great forward strides of technological advancement, every large producer of petroleum products maintains a staff of highly trained specialists who devote their talents to the development of new lubricants in a constant battle against man's great friend and enemy, friction.

Many new types of equipment and many new mechanical devices have been developed during recent years. To most people, however, the giant high speed diesel locomotives that thunder across the nation, the new planes that traverse continents and oceans in only a few hours' time, or the new washing machines that lighten the work of the housewife with

completely automatic operation, are but the expected manifestations of our advancing civilization. Few indeed understand the mechanical principles of their operation and fewer still give any thought to the lubrication of these devices. Modern lubricants perform their functions so smoothly that to the average man lubrication is no problem and he is concerned only when he is reminded by the corner filling station attendant that his car needs oil.

To the designing engineer, to the mechanical engineer, and to maintenance personnel, lubrication is a matter of deepest concern. To the lubricants research scientists, it is a challenge requiring a never ending search for better materials and combinations of materials to overcome the frictional forces which inevitably arise between surfaces moving against one another. In order to lubricate successfully the many new devices now appearing on the market, special oils and greases are necessary; the story of how a new grease comes into being is as interesting as the story of the development of the new equipment on which it is to be used.

Beginning of the Story

The story of a new grease often begins when some new type of mechanical device is first placed on the drawing board, for at that point a problem of lubrication may become apparent. Some new set of conditions—high temperatures, low temperatures, extreme centrifugal forces, excessive water washing conditions, extreme pressure, longevity of service in inaccessible places or a multitude of other factors may demand a grease having properties unlike any yet available. The grease technologist is then called in and the requirements of the new lubricant are outlined to him. Armed with this information, he then begins the work of developing the new grease.

The Nature of Greases

Greases are essentially mixtures of oils and soap in which may be incorporated special additives and other materials. They are not, however, simple mixtures. On the contrary, they are exceedingly complex, multiple-phase systems of which little of the true physico-chemical nature is even yet known. The problem facing the research technologist it not, therefore, simple or easy of solution. Very careful consideration must be given to the ingredients which must be used to make a product having the desired characteristics, as well as to the methods to be used in combining these ingredients.

Greases contain four fundamental types of ingredients: fats or fatty materials, a base (alkaline material) which is added to bring about the saponification of the fat, oily material (usually a petroleum oil), and finally, additives and other special materials which impart special characteristics. The grease technologist in approaching the problem of preparing a new grease must consider each of these types of materials in order to select ingredients which will impart the desired characteristics to the finished product.

The soap phase of the grease which is to be prepared is composed of a fatty material which is chemically reacted (saponified) with an alkaline

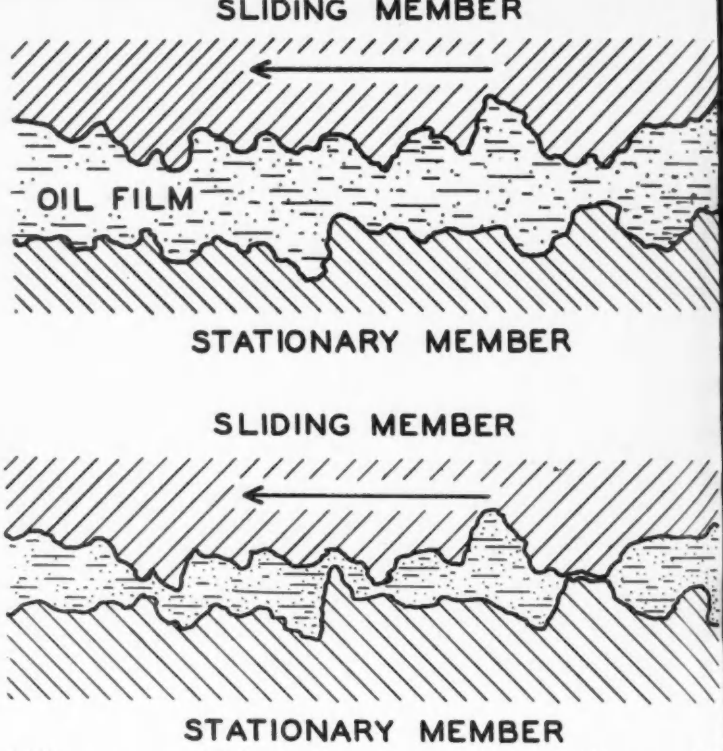
➤ GREASE KETTLES *where lubricants are mixed and blended.*

material. The effect of the fat and the base (alkali) must, therefore, be considered individually.

Fatty Materials

Fatty materials may be classified in several different ways. For the purpose of grease making, however, they may be classified as natural fats (glycerides), fatty acids, distilled fatty acids, modified fats and fatty acids, and synthetic fatty materials. Each of these classifications is in itself extremely broad. Space will not permit a full discussion of the many factors which affect the final choice of fatty material for a new grease. A few points of interest may however, be mentioned. Consider as an example the first classification, i.e., natural fats.

Natural fats may be broadly classified as animal, vegetable, and marine fats. Animal fats may be classified by origin, i.e., horse oil, beef tallow, hog fat, etc. Each of these fats has definite characteristics. But within even these sub-classifications, important differences exist. On first thought, the average person would probably conclude that hog fat, for example, is hog fat the country over and that



▶ WITH THICK-FILM *lubrication the moving parts are completely separated by an oil film, while with partial boundary lubrication the oil film is so thin that some of the high spots of the sliding member touch the high spots of the stationary member. The roughness of the surfaces is greatly exaggerated for purposes of illustration.*

the fat from one hog is the same as the fat from any other hog. The grease maker knows that this is not the case. The suitability of hog fat for grease manufacture depends on the methods used in processing the fat and on the length of time and the conditions under which it has been stored prior to use. Even further, the characteristicts of the fat depend to a certain extent on the feeting habits of the hog. Greases produced from the fat of northern hogs, for example, require a different ratio of oil to soap

▸ Rows of *grease drums stand ready for shipment to prevent wear on the world's machinery.*

for a given penetration (hardness) than do greases prepared from the fat of southern hogs. The reason is, simply that northern hogs feed on corn while southern hogs eat peanuts, cotton seed meal, and similar foodstuffs. As a result, the fat from southern hogs is less highly saturated (a technical term relating to the ratio of hydrogen to carbon in the fatty acid molecule), and the soap made from it is softer than the corresponding product from the fat of northern hogs. Differences of the magnitude spoken of here do not constitute a major problem since minor differences in fats may be determined by relatively simple chemical and physical tests and allowances may be made for these differences. They do serve to illustrate, however, some of the many factors which must be taken into consideration.

It can be readily visualized that if differences of this type are found in different lots of fat from the same species of animal, much greater differences are found between fats of different classification. In choosing the

fatty material, the source, method of preparation, average molecular weight and molecular weight distribution, degree of unsaturation of the fatty acids, the chemical nature of the unsaturated acids, and a number of other factors, all must be considered. The fat chosen must contain enough saturated acids to give the desired soap-to-consistency ratio, yet must contain enough unsaturated acids to give proper stability. But the unsaturated acids must be of such type as not to deleteriously affect the oxidation of the finished product. Obviously, the choice of a proper fatty material is not a simple matter nor one which can be intelligently made without a considerable background of knowledge of the effects of various types of fatty materials on the characteristics of greases made from them.

The Saponifying Agent

Having chosen a suitable fat or blend of fats for the application in question, the grease technologist must next choose a proper saponifying agent. Many materials are available for this purpose, although those most commonly used are the oxides or hydroxides of sodium, calcium, aluminum[1], lithium, or mixtures of these materials. To obtain special characteristics, however, barium, strontium, magnesium, lead, potassium, copper, and a number of organic bases may be used alone or in combination with any of the forementioned types.

Sodium soap greases have good high temperature characteristics, but relatively low water resistance (although water resistance may be improved by the use of proper additives or by the proper choice of mineral oils), and have normally a fibrous texture which results in but little propensity toward channeling although it does result in relatively high torque because of the drag of the fibrous material.

Calcium soap greases have, generally, relatively low melting points but excellent water resistance; they are characterized by their buttery texture. They have, therefore, a much greater tendency toward channeling than do sodium soap greases, but in consequence have much lower torque than the corresponding sodium soap products.

Mixed sodium-calcium greases have properties lying between the two extremes with specific properties dependent upon the ratio of the two bases.

Aluminum soap greases have a gel-like texture, moderate water resistance, very good resistance to centrifugal action and excellent appearance, but are limited in the temperature range over which they can be satisfactorily used.

Lithium soap greases have good water resistance, good high temperature characteristics, excellent low temperature characteristics, and a buttery to semi-buttery texture, but require special manufacturing procedures and high cost ingredients which prohibit their use in all applications where cost is a limiting factor.

Already it is clear that a large number of soaps can be prepared by proper choice of fatty materials or blends of fatty materials and using

[1] In the case of aluminum soap grease, usually the soaps are prepared by double decomposition rather than by direct saponification.

the many different saponifying agents (or combinations thereof). The choice of a proper soap which will give a grease of the desired characteristics is oft-times a choice beset by many possibilities. The choice must often be decided, in fact, by trial of several promising combinations.

The Oil

After a suitable fatty material and alkaline material (there are several possibilties) have been chosen, the grease research chemist must next turn his attention to the oil to be used. In the modern refinery oils ranging from highly refined oils to oils with but little refining, and from high paraffinicity to high naphthenicity, are available over a wide range of viscosities from light distillate oils to heavy residual oils. Facilities are available in fact to "tailor make" an oil to suit almost any demand. And in addition, to impart special properties to the proposed grease, synthetic oils—materials prepared by the chemical ingenuity of man, which possess properties superior in some respects to the best efforts of Nature—may be used.

No set rules can be laid down for the choice of the proper oil. In general, however, the choice is based on the type of service for which the grease is to be used. For slow moving loads high viscosity oils are used; for high speed bearings under light loads, low viscosity oils are used. For bearings operating over long periods of time without relubrication, oils of high refinement and oxidation stability must be used; for bearings where leakage is high and relubrication is frequent, more economical oils of lesser refinement and lower oxidation-stability may be used. For bearings operating under high temperature conditions, oils of high flash point and high distillation range to lessen fire hazard and prevent evaporation losses may be neccessary; pour point and viscosity index may be of little consequence. For bearings operating under extremely low temperature conditions, exactly the opposite will be true. Here again experimentation is usually necessary before a proper choice of oils can be made. Prior knowledge and experience are essential but the best oil blend must be chosen by experimentation from among several potentially acceptable combinations.

Additives

Having chosen the basic fundamental units of soap and oil for his grease, the research chemist must then choose the modifying agents which he wishes to incorporate in his grease to produce special properties. The field of choice here too is broad. Not many years ago the use of additives in greases was almost unknown; today additives to give extreme pressure properties, high melting points, oxidation resistance, increased tenacity or tackiness, water resistance, foam resistance, and other properties are available in a hundred different modifications and are widely used. The additive (or additives) used must be chosen, of course, on the basis of the intended service. The character of a grease may be quite changed by the proper use of additives; a calcium soap grease which would have a typical buttery texture without additives may be changed to a tacky, stringy, product by the incorporation of proper materials. Needless to say,

the choice is one of great importance. Decision as to the use of fillers must also be carefully made — graphite, metallic dusts, fiber, etc.—which although not commonly used, do fulfill a specific need for special purposes.

Number of Possible Greases

A moment's consideration will show that the number of possible combinations of all the fats, bases, oils, and additives is almost without limit. Aside from the possible combinations of known materials, however, cognizance must be taken of the applicability of materials not previously used. With the increase in demand for greases of new and unusual character, the grease maker must continually search for new materials to supply characteristics not available with the usual ingredients. This is, of course, a whole field of research in itself, but is, nevertheless, a factor which must be taken into consideration in the preparation of a new grease.

It is easily understood, then, that even after a choice of materials has been made, a considerable amount of work remains to be done in the laboratory. For example, if the research chemist decides to use as a fat blend in one type-formula a blend of hydrogenated fish oil and tallow, he still cannot say without trial whether the best results will be secured with a 50-50 blend, a 40-60 blend, a 60-40 blend, or some other ratio. He may determine that an oxidation inhibitor will be required, but the best of several inhibitors and the optimum concentration of the best inhibitor must be determined by trial. So too, the manufacturing conditions to be used must be determined. There is no standard manufacturing procedure which will suffice for all types of grease. Sodium soap greases, for example, are normally fibrous in texture; but by using the same ingredients and varying the manufacturing procedure, greases which are fibrous with long fiber, fibrous with short fiber, ropy, semi-buttery, or buttery, may be produced.

And so the new grease moves from the theoretical to the practical and experimental work is begun.

Grease Research

The modern grease research laboratory is an interesting place, with its kettles, scales, special mixers and other devices used in the modern compounding of greases. A multitude of test equipment is at hand—devices for measuring consistency, high temperature characteristics, leakage characteristics, extreme pressure properties, oil separation tendencies, and a number of other attributes vital to proper performance of the lubricant.

With this equipment experimental production and testing of greases is carried out. Many experimental batches are required—sometimes hundreds of batches—and many tests are necessary on each promising product. The mass of data thus accumulated must be subjected to careful analysis. Trends are established and pushed through to conclusion. The good is accepted; the bad is rejected. Gradually, by trial and elimination several promising products emerge.

The Field Test

Although laboratory tests are useful, field conditions often impose demands on the lubricant which cannot be foreseen or exactly duplicated in the laboratory. The most promising products must then be tried in operating equipment.

For the field trial a sufficient supply of the test grease is prepared in the laboratory and shipped to the site of application. The research chemist too, journeys to the scene of the trial in many cases. Here the grease is applied and its performance is closely followed, by the operators of the device, and by technical personnel. In the usual case, the best of the several products submitted can be determined. In the unusual case this best product is entirely satisfactory. Sometimes the lubricant is found deficient in one or several minor respects. In spite of broad experience and accuracy of work, all factors cannot be foretold. If the product is satisfactory it is ready for large scale production. If it is not, it must be returned to the laboratory for another period of trial and testing to bring about the modifications found necessary or desirable, and subjected to a second field test.

Plant Manufacture

Whether on the first trial or a subsequent trial, a satisfactory grease is finally found, plant scale manufacture must be then undertaken. The conversion to large scale preparation, naturally, must be studied and planned. Manufacture of 10 or 50 pounds of grease in the laboratory is one thing; manufacture of 10,000 or 50,000 pound batches in the plant may be quite another. Laboratory kettles are made to be small counterparts of the plant kettles. But differences do exist and these differences may require small changes in the ratio of ingredients or processing cycle. Plans must be made to deliver large quantities of materials to the plant grease kettle at the proper time and in proper proportion. Often new tanks for storage, new lines, and new pumps are required. In a few cases it may be necessary to design entirely new equipment to handle satisfactorily the manufacture of the new product.

In most cases, a mass of detail must be handled for the conversion; but most can be resolved on the basis of past experience. If plans are properly laid, the required product is satisfactorily made on the first attempt. It is tested, packaged, and shipped.

End of the Story

That is the story of a new grease, raised at last to its full status as a regular product. The story does not end here, however. The performance of this product, and all regular products must be carefully followed by field engineers. Through the years, modifications and improvements must be made to keep pace with the mechanical growth and progress of the equipment to be lubricated. No one can tell for how long the product will be manufactured. Entering an era of super speeds and atomic power, it seems certain that new greases will be constantly demanded, and that many of the products now manufactured will be no longer useful.

On the Back Cover

▶ Grease *in process of manufacture. The sodium soap which is the base of the lubricant appears in the top picture. In the middle, part of the oil has been added. The bottom picture shows the finished grease.*

Low Temperatures in Chemistry; Mesons in Physics Win Awards

Nobel Prizes in Science

➤ THE LOWEST temperatures ever reached by man, less than one one-hundredth of a degree above absolute zero, corresponding to 459.6 below below zero on the Fahrenheit scale, are due to the researches for which Dr. William F. Giauque of the University of California won the 1949 Nobel prize for chemistry.

One of the world's pioneers in low temperature research, Dr. Giauque proposed over 20 years ago the method of cooling below the temperature of liquid helium that uses what is known as the "adiabatic demagnetization of paramagnetic salts."

Dr. Giauque is planning a laboratory at the University of California which will contain the most powerful magnet in the world. For extending his low temperature researches, under the sponsorship of the Atomic Energy Commission and the Office of Naval Research, he hopes to build a one-hundred thousand gauss magnet. A gauss is a unit of magnetic attraction.

Before the award of the Nobel prize to Dr. Giauque, the University of California had earmarked half a million dollars for construction of the building in which the low temperature laboratory will be housed.

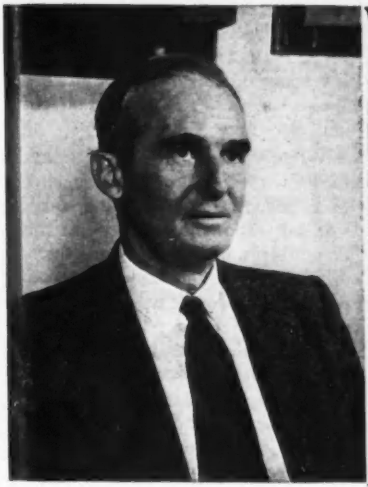
The most powerful magnet now in existence is a 40,000 gauss magnet at Leiden, in Holland. It was there that the first low temperature experiments were conducted about 40 years ago, including a test during which an electrical current was made to flow unimpeded for hours.

This persistent current experiment —a sort of "perpetual motion"—has also been startlingly demonstrated by R. B. Scott at the National Bureau of Standards. Cooling a lead saucer to about four degrees above absolute zero, a bar magnet is brought close to the saucer. This sets up an electric current in the lead which resists the further movement of the bar magnet toward the saucer. The magnet then floats above the saucer, literally suspended by nothing, like the legendary Mohammed's coffin.

So far no practical application of this achievement has been developed, but it is considered of great interest in understanding the properties of matter at very low temperatures. Some engineers have visualized transmission of electrical power with little loss over wires if they could be cooled down to the very low super-conducting temperatures, which are far below ordinary frigid temperatures.

New Mesons Predicted

➤ THE 1949 NOBEL PRIZE winner in physics, Dr. Hideki Yukawa, predicts that there may be many more elementary particles similar to the meson which he won fame by predicting. The Japanese physicist predicted an elementary particle 200 to 400 times as heavy as the electron in 1934, three



Dr. William F. Giauque

Dr. Hideki Yukawa

years before it was found in experiments with cosmic rays.

Dr. Yukawa now at Columbia University also predicts that these heavier "tau mesons" will be 800 to 1,000 times as heavy as the electron, but will be extremely hard to detect experimentally because they live only one-hundred-billionth of a second.

The original meson was predicted in 1934 as a means of explaining the attraction between protons and neutrons in the nucleus of atoms. When the predicted particle, with a mass 285 times the mass of the electron, was discovered in 1937, one of the names suggested for it was "yukon" in honor of Dr. Yukawa. "Meson," the name finally selected, was chosen because the particle is medium weight, heavier than the electron but lighter than the proton.

It was early suspected that the meson was more than one particle, and this suspicion was confirmed in 1947 by the discovery in cosmic rays of a slightly heavier meson 315 times heavier than the electron. It was called the pi meson. Pi mesons act as the binding force in the nucleus, as Dr. Yukawa originally predicted, and they decay into the lighter mu mesons, which were discovered in cosmic rays earlier, in 1937.

Pi and mu mesons have either positive or negative charges. There is also evidence for a neutral meson with a mass close to that of the pi meson.

At the present time, this extremely active branch of theoretical physics suffers from too many possible mesons. All may be predicted from different variations of the theory which Dr. Yukawa helped to develop, but

physicists cannot yet say which theory is the right one. It will be very difficult to find the whole family of these elusive particles by experiment alone because most of the heavier mesons, if they do exist, must decay too quickly to be observed by any of the methods now in use.

Peace Prize to a Scientist

➤ AWARD of the Nobel Peace Prize to Lord Boyd Orr, Scottish nutrition authority, marks the second time this award has gone to a scientist.

The previous award of the Peace Prize to a scientist came in 1922 when it went to Fridtjof Nansen, Norwegian Arctic explorer. Like Lord Boyd Orr, Nansen had turned from his scientific work in the field of exploration to problems of world hunger. At the close of World War I, Nansen directed relief work for famine-stricken Russia and later continued to direct two agricultural demonstration estates in the former famine areas.

"Nansen passports" owe their name to his work with refugees.

Lord Boyd Orr turned to problems of world hunger and their effect on world peace from the more conventional approach of researcher in nutrition. At Rowett Agricultural Research Institute in Aberdeen, Scotland, he organized surveys of the place of essential minerals, such as lime, salt, iodine and iron, in the diet of animals. He and his collaborators investigated the mineral content of the pastures of Britain, parts of Africa and elsewhere.

While in Africa he made a study, famous in scientific nutrition circles, of two African tribes living side by side but following different methods of getting a living and consequently different diets. One tribe which tended herds lived chiefly on meat, milk and blood. The other tribe lived chiefly on cereals, tubers. green leaves and peas and beans. Members of the first tribe averaged five inches taller and 23 pounds heavier and had much greater strength than the second tribe. In the first tribe, 60% of the children under eight years rated "very good" in health and nutritional state, compared to 7% of "very goods" in the second tribe. And members of the second tribe had much more tooth decay, softer bones, and more sickness than the first.

From this experience and further study of diets of humans, who, he used to say, were much worse nourished than their animals, he turned to the broader problem of hunger and the food supply in relation to world peace.

A synthetic transparent chemical has been perfected that absorbs 99.9% of the ultraviolet radiations of the sun for use in plastic goggle lenses.

Three ammonium sulfate plants have been authorized by the Portuguese government; they will have an annual capacity of 15,000 to 20,000 tons each.

Processing sealskins is a carefully guarded commercial secret; months are required to bring a skin from its raw state to its final silken luster.

Oxygen Molecules Energetic In Earth's Upper Atmosphere

Sun To Earth Energy Link

▶ A HITHERTO unknown layer of "energetic" oxygen molecules in the earth's upper atmosphere has been discovered by Dr. Joseph Kaplan, University of California at Los Angeles physicist.

It may prove to be one of the most important links in the chain along which solar energy passes in its journey from sun to earth, he says.

Lying in the ionosphere near the regions of the colorful aurora borealis and the softer greenish glow of the light of the night sky, this layer of "excited" molecules may be an important factor in the sun-powered earth's weather factory, thinks Dr. Kaplan. It also may perform a vital function in the extensive processing that solar energy undergoes before it reaches the earth.

Further investigation in this unexplored region may pave the way for accurate long-range weather forecasting, states the U.C.L.A. physicist. Learning what this region does with the enormous amounts of energy thrown out during sunspot activity may enable meteorologists to chart our weather months in advance.

Strangely enough, this new layer was first discovered not by rockets probing the vast reaches of the upper atmosphere, but in a bottle in a secluded laboratory at U.C.L.A.

Several years ago Dr. Kaplan first noted in a specially designed quartz bottle, in which gases were excited by electrical discharges, a new form of nitrogen molecule. Recently he discovered in the same bottle a similar form of oxygen. He called these molecules "energetic" or metastable nitrogen and oxygen molecules.

Considering the conditions under which these molecules were produced, he reasoned that a layer of such molecules existed in the upper atmosphere where these conditions were duplicated.

Current spectroscopic studies of the upper atmosphere by Dr. A. B. Meinel at the University of California Lick Observatory indicated verification of Dr. Kaplan's discovery.

The new layer is the fourth main layer to be discovered in the ionosphere that bounces back radio waves. Previously discovered layers are the E layer and the F1 and F2 layers, whose average heights are 70, 125 and 150 miles, respectively.

At present there is no way of knowing exactly where the new layer is located. "However, our knowledge of the conditions it takes to produce these particular molecules leads us to believe that it is located just below the ionosphere's E layer and just above the ozone layer, probably about 60 miles above the earth's surface," Dr. Kaplan says.

Temperatures at this height are almost zero degrees Centigrade, and the infra-red intensity is much more than had been previously supposed at this altitude.

Until the discovery of the new layer the ozone layer beneath was credited with being the sole shield that protected us from lethal ultraviolet rays. Now it is thought that much of the ultraviolet radiation is transformed to infra-red radiation in the newly-discovered layer above the ozone.

"We are now branching out from the laboratory phase of study of this new layer," Dr. Kaplan says. "As we probe it with rockets and other research tools, we may find that it is the missing link needed to fill out the puzzling chain of solar-terrestrial relationships."

Metals From Low-Grade Deposits

➤ THE THREATENED exhaustion of rich metallic ores is creating a world-wide interest in low-grade deposits and in better methods of recovering the metals from them. The United Nations Scientific Conference on the Conservation and Utilization of Resources received a report by R. W. Diamond, C. O. Swanson and B. P. Sutherland of the Consolidated Mining and Smelting Company of Canada, Ltd.

There are two types of ore deposits classed as low-grade. The first are simple ores of low metal content, and the second are complex ores containing a number of minerals. The recovery process depends upon the type.

In the first type, crushing and grinding form an important part of the total cost. The general trend has been towards larger sized units, together with the adoption of automatic controls and greater mechanization in the handling of materials. In the separation processes, gravity methods are especially suitable because they are inexpensive. Favorable results have been obtained from sink-and-float devices over a broad field. In addition, notable advances have been made in jigs, spirals, tables, flotation and magnetic separation.

The treatment of complex low grade ores covers a wider field because they can stand larger costs. The use of induced superficial oxidation, a fluidized bed for roasting and calcination, controlled crystallization of mattes, improved reagents in flotation, and electrostatic separation are some of the advances recently made. Automatic sorting of ore by visual differences, reflectivity, fluorescence, and transparency to various radiations has interesting possibilities.

During the past few decades the mineral industry has made great progress, and a good part of the progress has been achieved by industrial research and development using, in cooperation, the advances made in individual lines of science and engineering to further the industry as a whole. In North America, at least, there has been a remarkable recognition of the mutual advantage gained by the free interchange of technical information between individuals and companies.

Nitrogen-filled lamps of good life give about twice the candlepower for a given electric power than had been possible with the earlier vacuum lamps.

New Occupational Disease Discovered In England

Powder Poisons Policemen

➤ THE FINGERPRINT men in police departments are in danger of getting mercury poisoning from the dusting powder they use.

Discovery of this danger, which may be widespread in England and in the United States where the same mercury-chalk powder is used, was made when an outbreak of mercury poisoning occurred in the Lancashire Constabulary.

The cases, believed the first of this new occupational poisoning to be recognized, are reported by Dr. John N. Agate, and Monamy Bucknell of the Medical Research Council, the London Hospital, in the *Lancet*.

The Lancashire Constabulary consists of a detective chief inspector and some 32 detective sergeants and constables who specialize in taking and developing fingerprints at the scenes of crimes with mercury-with-chalk powder.

With the exception of one man, all volunteered to be examined. Of the 32, seven had symptoms of tremor which affected the hands in each case. Three of these also had tremors of the lips and tongue and three of the eyelids. Two other symptoms known to be caused by mercury poisoning were also present: loosening of the teeth and irritability and embarrassment which caused the men to blush easily.

Although their urine was examined for traces of mercury, this was not a good test for determining mercury poisoning. However, the amount of mercury excreted by the men was abnormally high.

Estimates were made of how many hours were devoted by the men to developing the latent fingerprints. The technique used is to apply the mercury powder with a soft brush and then to blow off or brush off the excess. One of the affected patients had been exposed for only 160 hours for one year while the others varied between 250 and 460 hours per year. The scientists conclude that 250 hours per year constitute a danger.

The mercury was believed to have been either inhaled by the policemen while they were dusting the fingerprints or from the mercury dust lying around the laboratory where they worked or it could have been absorbed through the skin. Some may have acquired the mercury by putting their hands to their mouth with the mercury dust on them.

Measures for protection, such as rubber gloves or masks, do not seem adequate to these scientists. They suggest that a substitute powder be found which will accomplish the same thing.

This was actually done in the Lancashire Constabulary by the officer in charge. When the origin of the trouble among his men was found he experimented and discovered a substi-

tute which is credited as being an improvement over mercury and forbade the use of the mercury compound.

Policemen who do fingerprinting as a part-time duty are not in much danger of being poisoned, the scientists stated. At the same time they pointed out that certain people may have a special sensitivity to mercury and the hazard for these would be real.

Poison in Plant Sap Kills Insects

➤ A CHEMICAL so poisonous to insects that it will kill them if they bite a plant that has taken it up through its roots was described before the meeting of the American Chemical Society at San Francisco by Dr. S. A. Hall of the U. S. Department of Agriculture. It is one of more than 300 organic phosphorus compounds originally produced by a German chemist, Dr. G. Schrader, the more promising ones of which are now being put through tests by the Bureau of Entomology and Plant Quarantine.

The compound, which has been so little known that it has no short common name or set of initials as yet, is octamethyl pyrophosphoramide. If it proves a practical means for enabling plants to poison their own attackers, it will probably be useful only on plants not intended for food, since most of the compounds in this group are toxic to human beings and domestic animals as well as to insects. However, it could still have large usefulness in the protection of fiber plants such as cotton and flax, as well as seedling trees, flowers and other ornamentals.

Fish Can Feed Millions

➤ FISH can feed the millions of growing population in the warm parts of the earth, a leading Indian zoologist stated at the United Nations Scientific Conference on the Conservation and Utilization of Resources at Lake Success recently. Almost any little body of water can be made to produce food at less cost and with a yield much higher than can be obtained from dry land farming.

Dr. Sunder Lal Hora, who is director of India's Zoological Survey at Calcutta, recommended that other countries follow the example of China, India and other Asiatic nations in raising fish for food, often in the same fields where rice is grown.

Not only do fish produce food for the table but they control the disease of malaria by feeding on the larvae of these insects.

A great advantage of fish farming is that it utilizes materials of the soil and added waste material without competing with ordinary farming.

Often two species of fish eating different kinds of food can be grown in the same pond, making the water do double duty.

Little capital is needed to start fish farming, Dr. Hora said, and pond culture promotes a happy village life as well as furnishing needed addition of protective food to the diet.

Electric Current Sent Through Deposit Sets It Afire Yielding Gas

Gases From Unmined Coal

➤ Fuel gases from coal as it lies underground in its natural seams have been successfully obtained by sending an electric current through the coal. The accomplishment was made near Hume, Mo., on property of, and with the cooperation of the Sinclair Coal Co.

As described by Dr. J. D. Forrester, chairman of the University of Missouri mining department, the process consists of making drill holes from the surface into a seam of coal lying below. Iron pipes are inserted into the holes to serve as electrodes. Connected with the electrodes is a series of pipes a few feet above ground through which the gas flows when it is generated.

A current of considerable voltage, controlled by a water rheostat, is sent down through the electrodes into the seam. In the process of passing through the coal and overcoming its electrical resistance, the coal is heated and begins to give off oil-saturated gas. This gas comes to the surface through the pipes that serve as electrodes. These pipes are 20 to 40 feet apart.

After the coal bed becomes sufficiently heated so that it will burn and yield other gases, the electric current is stopped and air or oxygen is pumped into the coked and porous coal seam to sustain further combustion. This continues the supply of gases from the actual gasification of the undeground coal.

The gases produced by this so-called electrocarbonization process can be used as raw material from which to make synthetic gasoline, or can be converted into a heating fuel. The gas produced is similar to the coke furnace gas of surface plants. Field tests were preceded by laboratory experimentation during which it was proven that coal can be turned into gas by an electric current. Both laboratory and field work was done by Erich Sarapuu, a research fellow of the University's School of Mines and Metallurgy.

Several test runs on coal layers have been made during the past year. Some oil-tar has been collected at Hume along with the gas. In addition, laboratory investigation with oil-sand has resulted in the production of crude oil, as well as gas.

Fuel gases from underground coal are being successfully obtained by the U.S. Bureau of Mines in experimental work at Gorgas, Ala., in a joint project with the Alabama Power Company. No electric current is used, however, in the gasification process. Underground burning is employed.

Two holes are sunk into the coal seam, and fire started in one by use of an incendiary bomb. Air under pressure is forced in to feed and spread the fire, and the gases of combustion are driven by the same air pressure to the second hole, from the top of which they are captured. Some-

what similar work is being done in several European countries, particularly in Russia, where the scheme is said to have originated.

Electricity is used, however, in an oil-recovery process from oil shale in Sweden. A deep hole is drilled into the underground layer of shale, and an electrical heating element is lowered into the hole. The oil from the shale is driven off by the direct heat generated.

Influenza Virus Made Radioactive

➤A WAY to make influenza virus radioactive is announced by two Canadian scientists, Drs. A. F. Graham and Laurella McClelland of the University of Toronto.

Their idea was not to make the 'flu virus any deadlier, but, instead, to learn more about the mechanism of its synthesis, or growth, in the cells of the body.

They injected influenza virus into the fertile hen's eggs and then three hours later injected a solution containing radioactive phosphorus. In one of the experiments the radioactive solution injected into each egg registered 57,000 counts per minute on a Geiger-Muller counter.

After about 48 hours the virus which had been growing in the eggs was harvested and purified. Geiger-Muller counts and other tests showed that the virus had taken the radioactive phosphorus into its structure just as it would have taken up ordinary phosphorus.

Lightweight Geiger Counters

➤ A ONE-POUND Geiger counter for uranium prospecting, developed by the Canadian National Research Council, together with several weighing from six to 11 pounds, makes possible a systematic search for this essential atomic energy mineral without the use of the much heavier Geiger counters usually used.

Radium and uranium prospecting before the war was largely a hit-and-miss affair, based principally on visual observation. Geiger counters eliminate the hit-and-miss method because this electronic instrument, now used for many years in detecting radioactivity, will register even trace amounts of radioactive substances. Several lightweight portable types have been developed since uranium has become so important in the atomic energy field, but none, as far as known, as light as the new Canadian one-pound, pocket-size instrument.

The Geiger-Mueller tube, the heart of the counter, is small in itself. Its power requirements at first were disproportionately large. Portable counters were made possible by the new miniaturizing techniques used in the construction of electronic circuits.

This Canadian miniature Geiger counter may be lowered by cable into a deep drill hole in a search for any radioactive material through which the hole might have passed.

Many Fuels and Combinations Being Tried In NACA Research

Better Fuels for Rockets and Jets

▶ BETTER FUELS for rocket and jet engines are promised for the near future as a result of research at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics at Cleveland. Equally important are engines under development capable of delivering the extremely large powers required for supersonic speeds.

All sorts of fuels and fuel combinations are being tried. Some have been found that experimentally give far better results than those now in general use. One studied is 2.5 times as powerful. Particularly important is the research work to develop better jet engines able to withstand the very high temperatures at which they operate, and to construct them of materials available in the United States, or at least in the Western Hemisphere. America, in national emergencies, needs independence from imports.

With the increasing use of rockets and ram-jet engines to give combat planes greatly increased power for short periods in emergencies, fuels that will ignite at the extremely low temperatures encountered at high altitudes are essential. Also essential are fuels whose flames will not blow out in the speeding ram-jet.

Rocket fuels, which at low altitudes and moderate temperatures ignite spontaneously and rapidly upon contact, may refuse to ignite at all at high altitudes, or they may ignite in explosive fashion destroying the rocket engine. Two solutions are being worked out at the Lewis Laboratory. One is to keep the engines and the fuels sufficiently warm to insure prompt and safe starting. The other is the use of added substances to the fuel to shorten the ignition lag.

The ram-jet engine, unlike the rocket, depends upon oxygen from the air for combustion. It scoops up the air as it flies at rapid speed through the atmosphere. It can operate only after it is up to a speed of some 300 miles an hour, a speed that it can acquire from its carrier plane if it is to be used to give spurts in emergencies, or a speed that it can acquire from carrier rockets if it is launched from the ground.

Because the air in a ram-jet passes through the combustion chamber at high speed, there is a tendency for the flame to blow out. Operating the engines at high altitudes with resulting low pressures also makes combustion difficult. Since 1945, the velocities at which good combustion efficiencies can be maintained have been increased three-fold, and further progress is expected. Similar progress has been made in increasing the altitude limits for satisfactory combustion, a result of intensive research on flame-holding devices, fuel-injection methods, and combustion chamber design.

Present jet engines of the type used in jet fighters and bombers burn a kerosene-type fuel. When a barrel of

crude oil is refined, only 6% of the resulting products is kerosene. Present plans are to use in the future about 50% of the products refined from a barrel of crude, a mixture that would contain all the kerosene and gasoline and about one-fourth of the diesel and heating oils in the petroleum. As a result of NACA's work, new jet fuels have been specified meeting this availability maximum from crude oil and they are substantially equal to or better than the kerosene-type fuels now used.

New Rubber for Severe Conditions

➤ A NEW SERIES of specialty rubbers that can withstand dry heat up to 400 degrees Fahrenheit and also are highly resistant to gas, oils, ozone and sunlight were described to the American Chemical Society by H. P. Owen, technical service engineer for the B. F. Goodrich Chemical Company, Cleveland, Ohio.

Designated as the Hycar PA series, these rubbers are expected to find use in the manufacture of a wide variety of products where service conditions are too severe for ordinary rubbers.

Heat and oil-resistant hose, mats, pads, air bags, protective coatings on heat-resistant fabrics such as glass and asbestos, sunlight-resistant temporary coatings on rubber goods such as deicers and tires, and insulation on wire are among the possible uses. Gaskets transmission and conveyor belts, and white or pastel colored products requiring color permanence also were listed. White goods made from this type of rubber have "unsurpassed resistance" to discoloration in sunlight, according to Mr. Owen.

The name of the new rubber series —Hycar PA—is derived from hydrocarbon and polyacrylic, which in turn are the names of the types of compound from which the rubbers are made.

Research and development work on the Hycar PA rubbers began at the B. F. Goodrich Company in 1942, Mr. Owen reported, but the program had to be curtailed for the next few years because of more pressing wartime needs. In 1945, however, intensive research on the manufacture of flexible rubber compounds for high temperature service was resumed, leading to the current series.

Tracers Hunt Sulfur in Steel

➤ RADIOACTIVE isotopes from the chain-reacting piles of the Atomic Energy Commission are helping scientists discover just how undesirable sulfur gets into finished steel.

Mixed with 12 tons of coal in a coke oven at the Republic Steel Corporation at Cleveland, O., radioactive sulfur atoms were used as tracers. The experiment is believed to be the largest-scale use of radioactive isotopes yet attempted. It proved that the sulfur is carried over from the coal into the coke used in making steel.

American Metal Promising For High Temperature Engines

Molybdenum for Jet Engines

► THE AMERICAN metal molybdenum promises to play an important part in high-speed aviation in the near future. Researches at Battelle Memorial Institute, Columbus, Ohio, show that this metal can be used more largely than at present in the construction of jet and rocket engines to operate at the extreme high heat necessary for efficiency.

The attainment of more compact and efficient power plants depends, in part, on the perfection of heat-resisting materials superior to those available today, Robert M. Parke, Battelle's specialist upon refractory metals, points out. Extensive investigations are being conducted, with Office of Naval Research support, with the primary objective of raising the usefulness of molybdenum to a level consistent with its abundance.

Present requirements for heat-resistant metals are being met largely by alloys in which iron, nickel, or cobalt are major constituents, Mr. Parke states. To make any substantial increase in the operating temperature of the metal parts of heat engines, a metal must be selected which has a melting point greater than that of iron, nickel or cobalt. These are 2,800 degrees, 2,700 degrees, and 2,650 degrees Fahrenheit, respectively.

All metals with melting points above 2,800 degrees are either difficult to fabricate or scarce, or both. Molybdenum has a melting point of 4,750 degrees. It is abundant, particularly in the United States. Although not now easy to fabricate, it seems certain that improved methods will be found. This is one of the problems that Battelle Institute hopes to solve.

In addition to its high melting point, molybdenum has other properties which can be expected to contribute to its successful use as a heat resistant metal in aviation power plants and other applications. It conducts heat about twice as well as iron and its coefficient of thermal expansion, its rate of expansion when heated, is among the lowest of pure metals. The magnitude of these properties will aid in preventing distortion due to high heat.

One disadvantage of molybdenum is its inability to resist rapid oxidation above 1,400 degrees Fahrenheit in air. Above this temperature it forms an oxide that evaporates as rapidly as it is formed, thus giving no protection to the metal. This constitutes another problem to be solved, but solution is promised.

Alcohol and complex alkaloids of the opium poppy were the first drugs used in medicine to relieve pain from disease or injury.

Tetraethyl lead is contained in all gasoline used by the American air force.

New Metallic Forms Make Better Metals

New Metals Forging Forward

by A. C. MONAHAN

SUCH NAMES as titanium, tantalum, tungsten, molybdenum and zirconium will soon roll from the tongue of the man-on-the-street as easily as do now the names of such common metals as steel, tin, lead, zinc, aluminum and magnesium. These little-known metals, and many others, are rapidly coming to the front because of their increasing use in metallic forms, or in alloys which are far superior to the well-known common metals.

Aluminum some 60 years ago was called a "luxury metal" and cost about five dollars a pound. Magnesium today is becoming as well-known as aluminum and can be produced cheaply in as large a quantity as needed. Titanium is still a "luxury metal" but new methods of obtaining this element from the plentiful ores in which it occurs give promise that titanium will some day compete with steel for structural uses.

Many of these now little known metals may never be used in pure metallic form, but will find their principal employment alloyed with steel or other base metals to give to them properties now needed in modern mechanics which these base materials do not possess in themselves. In fact, many of them are already in use and have given common steel products far greater strength, hardness and ability to resist high heat and corrosion. Aircraft jet-propulsion, as we know it today, could not exist without the help of what might be called the rarer metals.

Chemists have known for years all the rarer metals occurring in the crust of the earth, and have isolated most of them in small quantities for laboratory purposes. It is only relatively recently that they have begun to appreciate the important part that some two to three dozens of them can play in modern metallurgy to replace common metals facing exhaustion, or to use with the common metals to get better alloys.

Americans were long taught to believe that the supply of common domestic metals was inexhaustible. They are now awakening to the true situation. Increasing uses of these minerals due to the growth of the machine age and the use of metals in construction are fast using up the known reserves. Many of them can be obtained from abroad, but this would be of little value in a world-wide war. It was America's available metals that built the war equipment that recently humbled the Nazi and Jap enemies. A nation's independence depends largely upon its self-sufficiency in metals.

The rapid depletion of available ore in American mines is now a matter of national concern. The U.S. Bureau of Mines and the Geological Survey are extending every effort in a search for new deposits of such common metals as iron, copper, lead and zinc, as well as for the little-known metals that can be used as substitutes or in alloys with these basic materials. Congress has a

COPPER *once formed a hill in Nevada, where above-ground mining has now reduced the site to the pit shown above. Depletion of our metals resources is causing national concern.*

bill before it which is designed to promote the production of strategic and critical ores, metals and other minerals. The bill would establish in the Department of the Interior, in which the two agencies mentioned now are, a Mine Incentive Payments Division which would help mining financially when needed.

Steel is in many ways the number one metal in American progress but steel is an alloy made up largely of iron. Modern life uses much steel but relatively little iron. The so-called Age of Machinery and the Age of Steel are parallel. Iron has been used for over 4,000 years, but it played only a minor part in human life until steel was developed. It is steel that made modern machines and tools possible, and also the construction of giant buildings, bridges and ships, as well as railways, railroad cars and automobiles.

There is little free iron in the world. It is found in various compounds of which the iron oxide known as hematite has furnished the world with most of the iron used. Credit for the process

➤ NEW ALLOYS *form the vanes used in jet turbine engines, where the working temperatures would be too high for many old-time metals.*

of smelting ore to obtain iron goes back to about 2,000 B.C. and to the Hindu people. Most of the metal produced was relatively low in grade until the discovery of steel.

High-grade metals, however, were sometimes produced during the many centuries, but they were largely accidental. It happened that the ores used contained some of the rarer metals which remained in the finished product, imparting qualities of strength and hardness which modern metallurgists are now producing under scientific control.

America has plenty of iron ore distributed from Massachusetts to the west coast, but most of it is low grade and recoverable only at great cost. The high-grade ore, such as that from the famous Mesaba region in Minnesota, is rapidly being used up. Copper, lead and zinc are other basic metals, with American sources facing exhaustion. Imports could take care of needs for many years to come under normal conditions. Government officials state the domestic supply of known copper reserves will be mined out in about 20 years. The same is true for zinc. Lead will last only about half that time. The development of substitutes is one way to prolong their availability.

A good example is the growing use of aluminum wire to replace copper in electrical installations. Aluminum will be available for many years. Although most of it is now obtained from imported bauxite, it can be gotten from domestic clays, although present methods are more costly than its reduction from bauxite.

Shorter names may have to be found for some of these rarer metals as they come into common use. Aluminum in England is still aluminium. A familiar name for aluminum and magnesium among some workmen in the aircraft industry is "Al" and "Mag." Molybdenum, already an important alloy in steel, yields a high heat-resistant product often called moly-steel. The high melting point of molybdenum, about 4,750 degrees Fahrenheit, is one of its principal features. It is a plentiful metal in America, and promises to become important as a structural metal when cheaper methods of getting it from its ores are developed.

Tantalum has an even higher melting point than molybdenum, approximately 5,200 degrees Fahrenheit, but it does not exist in large enough quantities, as far as now known, for large-scale uses. Some is mined in the United States but the largest tantalite producer in the world is in the Belgian Congo, Africa. Its high melting point makes it suitable for special applications, including an extended use in high-vacuum radio tubes. It is an inert metal, highly resistant to chemical reaction, and is already widely used in surgery because it is not attacked by the fluids in the body.

Zirconium is a sister metal of titanium but, because of its high resistance to attack by many acids, may replace the scarcer tantalum. Although America imports some zirconium, it has a good domestic supply, this metal occurring in the same ilmenite and rutile minerals that yield titanium. High-temperature refractories, vitreous enamels and electrical and chemical porcelain now share its use with metal alloys. One possible future application is as a structural material in atomic power plants.

There are many applications in which lightness in weight on the part of a metal is an essential property. Before the days of aluminum, metals were thought of as being something heavy. The lightness of aluminum was its most surprising quality. Then along came the much lighter magnesium. The public is not as familiar with magnesium as with aluminum because much of it reaches them in an alloy with the aluminum. These alloys, from some 10% to 25% magnesium, are harder, lighter, stronger and more easily shaped by machinery than aluminum alone.

The really light metal of the future is lithium. It weighs approximately one-fifth as much as aluminum. It is the lightest metal known. In fact, it is said to be the lightest solid known with the exception of frozen hydrogen. It is a silver-white metal, more plentiful in the crust of the earth than lead or tin. Ten years ago it was little known outside of the laboratory. Today, it has many applications.

Lithium metal is used as a hardener in lead and aluminum alloys. It and its compounds are used in high-conductivity copper castings, tin bronzes, silicon bronzes, aluminum welding, magnesium welding, and in the heat-treatment of metals. Compounds are used in storage-battery electrolytes, in photography, in pottery, and as a coloring agent in signal lights.

Paint Blue-Prints Its Own Flaws

➤ Invention of a portable instrument which examines painted surfaces and makes a blueprint of all tiny flaws and holes marking the beginning of paint failure was announced by Professor Max Kronstein, Marion M. Ward and Robert Roper of the New York University College of Engineering to the American Chemical Society.

Professor Kronstein and his associates have previously developed a way of blueprinting minute failures in paint applied to steel and iron. Paper soaked with a salt solution is sandwiched between the painted surface and a sheet of aluminum, the two metals are connected to an electric battery, and iron particles are carried by the current through holes in the paint and deposited on the paper. Here they are chemically developed into bright blue spots.

The new instrument is an improvement on the old process because it can be plugged into an ordinary electric outlet, thus doing away with the need for heavy and expensive batteries. It is light enough to be employed in field testing. Developing solutions have been discovered for metals other than iron, so that now paint coatings on aluminum and cadmium, for example, can be tested.

Some of these metals do not themselves deposit brightly colored salts on the moist paper, but the N.Y.U. researchers have found methods of dyeing the normally colorless salts without coloring the rest of the paper.

Sulfanilamide fed to laying hens resulted in many eggs without shells; sulfapyridine had no similar effect.

For The Home Lab

Acetanilide

by Burton L. Hawk

➤ The practical home chemist will utilize those reagents he has, to prepare others which he does not possess. In this way he can gradually increase his stock of reagents as well as his knowledge of chemical reactions.

Acetanilide is one such compound that can be prepared easily, purified and bottled for future use. And no doubt you will find it useful, as it is important in the formation of many other organic compounds, in the manufacture of synthetic dyes, and in pharmaceutical preparations.

Preparation

The process used in the preparation of acetanilide is known as *acetylation*, which is simply replacing the reactive H atom of aniline with the acetyl radical. This is usually accomplished by reaction with acetic acid. Alcohols, phenols, primary and secondary amines are capable of direct acetylation. In the preparation of aspirin, (*Chemistry, March, 1947*) we described the acetylation of an acid, (*Salicylic acid*.) Now we are concerned with the acetylation of an amine, *aniline*.

Mix together 5 cc. each of glacial acetic acid and acetic anhydride. Now carefuly add 5 cc. of aniline in small portions, shaking after each addition. For best results the aniline should be colorless. If your aniline is colored brown, due to exposure to air and light, then distil it immediately before using. Use caution in distilling, as aniline is flammable and poisonous.

Place the mixture of the three A's into a large flask and apply gentle heat. Allow the liquid to boil for thirty minutes. After this time, pour the hot liquid into a large beaker of cold water, stirring rapidly. The acetanilide crystallizes out in such profusion and rapidity that it is a joy to behold. Would that some other compounds would crystallize as easily!

Acetic anhydride was added to hasten the reaction. However, acetanilide can be prepared by using acetic acid alone. Mix together 10 cc. of aniline with 12 cc. of glacial acetic acid. Place in a large Florence flask. Apply heat and allow to boil gently for about five or six hours. (If you have a long air-cooled reflux condenser, you can hasten the reaction by fitting it to the flask.) Then proceed as before, pouring the hot liquid into cold water.

Purification

When you prepare compounds that you intend to keep, it is essential that they be as pure as possible.

Drain the water from the acetanilide crystals, and add about 50 cc. of hot water to them. Bring the solution to boiling, when the acetanilide will melt to a heavy oil. Continue to add *small* portions of hot water until the acetanilide is completely dissolved. Then immediately add about one gram of decolorizing charcoal, and boil again for about ten minutes. Finally, heat a glass funnel by invert-

ing on a steam bath. Dry quickly, add a fluted filter and pour the hot solution through the *hot* funnel, allowing the filtrate to drop in a clean beaker. It is important to keep the solution hot at all times or else the acetanilide will crystallize out before it is filtered. The filtrate in the beaker is now cooled; the crystals are filtered off, washed with cold water, and dried by spreading them out on a sheet of absorbent paper, such as a blotter or paper towel. When *thoroughly* dry, place the crystals in a clean bottle, label "ACETANILIDE," with the formula, $C_6H_5NHCOCH_3$, and the date of preparation.

Reactions

Detection: If acetanilide be added to dilute chlorinated lime solution and a small crystal of carbolic acid added, a light blue color develops.

Dissolved in HCl, acetanilide produces a light green color when a drop of potassium permanganate solution is added.

Odor of Strawberries: Mix a small quantity of acetanilide with an equal quantity of boric acid. Fuse the mixture until it turns yellow. Allow to cool slightly, then moisten with a little water. With a little imagination, you will be able to detect an odor similar to that of strawberries.

Uses

Acetanilide is used widely in medicine under the name, *antifebrin*. Like aspirin, it is helpful in relieving pain in headache, neuralgia, sciatica, etc. Externally, it is used as an antiseptic dusting powder. It is added to many commercial preparations of hydrogen peroxide as a stabilizer.

New Radio-Activity Measuring Device

➤ A NEW device for measuring radioactivity may replace the Geiger counter in certain phases of atomic research.

The instrument, an alpha scintillation counter, has been developed by Dr. Benedict Cassen, Clifton Reed, Leonard Baurmash and Lawrence Curtis of the Atomic Energy Project on the Los Angeles campus of the University of California.

In low rate counting problems encountered in some health, physics and dust study applications, Geiger counters have not been entirely satisfactory. Long runs are necessary to obtain statistically adequate numbers of counts in view of the background caused by cosmic radiation. Frequently Geiger counters become insensitive or give erratic groups of counts in this type of research.

The new type of counter eliminates these obstacles, functioning more efficiently on low rate counting problems. Its greatest utility is in measuring very slight amounts of radioactivity in dust, soil samples, and ashes of biological specimens. The basis of operation is the measurement of alpha particle scintillations by photo-multiplier tubes.

The device is about the size of a table model radio and is entirely automatic once the radioactive sample to be measured is inserted and its mechanism started.

Mystery of Light Phenomena Cleared by Changing Viewpoint

Energy, too, Is Atomic

▶ As INFORMATION about the atom accumulated from study of light given off when chemical substances are excited by heat or other forms of energy, discrepancies began to appear. People had always assumed that energy flows in a smooth stream, but during the early years of the twentieth century more and more cases turned up in which the experimental facts would not fit equations based on that assumption.

Max Planck at the very beginning of the century had made the announcement that radiation is emitted in bursts or gusts, units which he named "quanta." Other physicists then set themselves to changing over the well-known laws to accord with the new concept. Out of that struggle came a new branch of mathematics: wave mechanics.

The following extracts from an early paper by de Broglie show how he attacked the problem. Those interested in following the mathematical development are urged to work through the reasoning in the complete paper, available in many libraries.

De Broglie Tests Quantum Theory

A TENTATIVE THEORY OF LIGHT QUANTA *by Louis de Broglie. Philosophical Magazine, 6th Series, Vol. 47, Jan.-June 1924.*

▶ THE EXPERIMENTAL evidence accumulated in recent years seems to be quite conclusive in favour of the actual reality of light quanta. The photoelectric effect, which is the chief mechanism of energy exchange between radiation and matter, seems with increasing probability to be always governed by Einstein's photoelectric law. Experiments on the photographic actions, the recent results of A. H. Compton on the change in wavelength of scattered X-rays, would be very difficult to explain without using the notion of the light quantum. On the theoretical side Bohr's theory, which is supported by so many experimental proofs, is grounded on the postulate that atoms can only emit or absorb radiant energy of frequency ν by finite amounts equal to $h\nu$, and Einstein's theory of energy fluctuations in the black radiation leads us necessarily to the same ideas.

I shall in the present paper assume the real existence of light quanta, and try to see how it would be possible to reconcile with it the strong experimental evidence on which was based the wave theory.

For the sake of simplicity, it is a very natural assumption to admit that all light quanta are identical and that only their velocities are different. We shall then assume that the "mass at rest" of every light quantum has a given value m_0: since the atoms of light have velocities very nearly equal to the Einstein's limiting velocity c,

they must have an extremely small mass (not infinitely small in a mathematical sense); the frequency of the corresponding radiation must be related to the whole energy of a quantum by the relation

$$h\nu = \frac{m_0 c^2}{\sqrt{1-\beta^2}}, \qquad \left(\beta = \frac{v}{c}\right);$$

but, since $1-\beta^2$ is very small, we can write

$$\beta = \frac{v}{c} = 1 - \tfrac{1}{2}\frac{m_0^2 c^4}{h^2 \nu^2}$$

The light quanta would have velocities of slightly different values, but such that they cannot be discriminated from c by any experimental means. It then seems that m_0 should be at most of the order of 10^{-50}gr.

Naturally, the light quantum must have an internal binary symmetry corresponding to the symmetry of an electro-magnetic wave and defined by some axis of polarization. We shall refer again later to this remark. . . .

Open Questions

The conceptions stated in this paper, if they are received, will necessitate a wide modification of the electromagnetic theory. The so-called "electric and magnetic energies" must be only a kind of average value, all the real energy of the fields being probably of a corpuscular fine-grained structure. The building up of a new electromagnetism seems to be a very difficult task, but we have one directive idea: according to the correspondence principle and to the above statements, the defining vectors of the old electromagnetic theory would give the probability of the reaction between matter and fine-grained energy.

The new electromagnetism will give the solution of many problems. The laws of propagation of waves given by Maxwell's theory will probably be valid for the energyless light phase waves, and the scattering of the radiant energy will be explained by the resulting curvature of the rays (viz., light quanta paths). There seems to be a great analogy between scattering of radiation and scattering of corpuscles; lowering of particles' velocities by crossing through a screen may also be similar to the lowering of X-ray frequencies by scattering, which recently has been computed and experimentally checked by A. H. Compton.

Explaining optical dispersion will be more difficult. The classical theories (including the electron theory) gives only an average view of this phenomenon, which is produced by complex elementary reactions between radiation and atoms; we shall certainly be obliged here also to distinguish accurately the real motion of energy from the propagation of the resulting interference state. The kind of "resonance" shown by the variations of refractive index seems no longer to be irreconcilable with discontinuity of light.

Many other questions remain open: What is the mechanism of Bragg's absorption? What occurs when an atom passes from a stable state to another, and how does it eject a single quantum? How may we introduce the granular structure of energy into our conceptions of elastic waves and into Debye's theory of specific heats?

Finally, we must remark that the quantum relation remains still a kind of postulate defining the constant h whose actual significance is not at all cleared up; but it seems that the quantum enigma is now reduced to this unique point.

Summary

In the present paper it is assumed that the light is essentially made up of light quanta, all having the same extraordinarily small mass. It is shown mathematically that the Lorentz-Einstein transformation joined with the quantum relation leads us necessarily to associate motion of body and propagation of wave, and that this idea gives a physical interpretation of Bohr's analytical stability conditions. Diffraction seems to be consistent with an extension of the Newtonian Dynamics. It is then possible to save both the corpuscular and the undulatory characters of light, and, by means of hypotheses suggested by the electromagnetic theory and the correspondence principle, to give a plausible explanation of coherence and interference fringes. Finally, it is shown why quanta must take a part in the dynamical theory of gases and how Planck's law is the limiting form of Maxwell's law for a light quanta gas.

Many of these ideas may be criticized and perhaps reformed, but it seems that now little doubt should remain of the real existence of light quanta. Moreover, if our opinions are received, as they are grounded on the relaitvity of time, all the enormous experimental evidence of the "quantum" will turn in favour of Einstein's conceptions.

Canada's Bombless Atom Work

▸ Untroubled with the problems of building bombs, Canada's atomic scientists are "doing a splendid job," an American scientist declares.

Dr. Milton Burton, professor of chemistry at the University of Notre Dame, says Canadian scientists are giving the world a lesson in peace. Dr. Burton recently returned from a visit to the Canadian atomic energy project at Chalk River, Ont.

Avoidance of the military problems associated with atomic energy permits the Canadians to concentrate on fundamentals—on those aspects of atomic energy which are of real and lasting value, on the acquirement of fundamental knowledge, on the development of new horizons and on the extension of application of atomic energy for peace, according to Dr. Burton.

"Canada is too small a nation to devote itself to the military aspects of atomic energy," the scientist explained, adding, "For a small nation at atomic bomb war is simply inadmissable.

"As a matter of fact, undue concern with the military aspects of atomic energy may be a snare and delusion for any nation, because an atomic war can be fatal for all of us."

Delicate Sense Perceptions Analyzed for Chemical Causes

Flavors Interest Food Chemists

➤ AMERICA's cooks were advised that familiar flavors guarantee the success of any dinner, by E. C. Crocker of Arthur D. Little, Inc., Cambridge, Mass., who discussed the philosphy and psychology of flavor at the national meeting of the American Chemical Society.

Mr. Crocker, speaking at a symposium of the Society's Division of Agricultural and Food Chemistry, reported that the most familiar flavor is usually the most popular. He pictured any remembered flavor as likely to pass a mental "testing board," regardless of other qualifications.

It doesn't matter so much whether some humble flavor or something highly sophisticated is involved, he explained. The big thing is that it must be known to win prompt acceptance.

He cited a recent test which a brewery conducted among the families of its employees. Only two weeks was required to switch their preference from their own brand to that of a competitor.

At the end of the test period, Mr. Crocker stated, each employee was asked to sample and to select the beer he liked best, from similar unlabeled bottles containing the competing articles and the home product. In each instance the employee, by this blind test, chose the beer that he had been using for the past two weeks.

The same principle holds true for foods, Mr. Crocker said.

Describing flavor as "a means of communication from the food," Mr. Crocker said it results from smell, sight, hearing, and "mouthfeel," as well as taste. He pointed to silent soups and the crunch of raw onions as instances in which hearing heightens flavor.

Chemistry has found ways to analyze only a few flavors. Some essential oils may be appraised by a technique of infrared spectral analysis, which makes use of invisible light. But most flavor evaluation still has to be done by human tasters, preferably trained tasters who can offer clear reasons for their likes and dislikes.

Flavors sometimes counterfeit sensations, Mr. Crocker declared, citing the pseudo-coolness of menthol and peppermint and the pseudo-warmth of alcohol or ginger, where there is no actual change in temperature.

Turning to the flavor of commercial products, the Massachusetts chemist said that continued sales of any edible product are linked closely to its continuing flavor. He declared that most manufacturers who lowered the quality of their products during the war have been too cautious concerning its restoration.

Flavor takes the bitter with the sweet, Mr. Crocker said, adding:

"Pleasantness of flavor is due to more than the summation of just pleasant factors. We like many things that are not sugar-coated, or even mild. Raw onion or a little garlic may

be the making of a salad, rancidity of the fat and moldiness besides are what is characteristic of the Roquefort or blue type of cheese, and tartness is a reason for the use of lemon juice or vinegar. Mustard, pepper and other spices actually pain the mouth. People like occasional strong tastes for contrast and also they sometimes want blandness. What might be called a defect for one food may be necessary to complete another food. Therefore, fidelity to type rather than intrinsic pleasantness is a strong factor in flavor."

Human Noses for Tests

▶ A PANEL of trained palates and noses has been able to solve flavor problems which defied chemical analysis, L. E. Cartwright of Foster D. Snell, Inc., N. Y., told the meeting.

Mr. Cartwright reported three specific instances where sensitive human perception, used in a new research tool termed "panel testing," has improved the odor and flavor of products after established chemical tests had failed. He declared that such evaluation has proved extremely important in solving many commercial problems. His paper was prepared in collaboration with Drs. Cornelia T. Snell and Patricia H. Kelley.

It was found, Mr. Cartwright reported, that unopened cartons of a popular brand of cigarettes had a bad odor. They smelled as if they had been left in a damp, musty cellar for months. The problem of finding the cause of the trouble was brought to a consulting laboratory for solution, where a panel-testing technique was applied. In this case it was a question of evaluating odor, which resembled that of a particular insecticide.

The objectionable odor came not primarily from the cigarettes, but from the cardboard of the cartons. Fresh cartons were impregnated with increasing amounts of the suspected insecticide. This led to verification of the identity of the contaminant, and also to determination of the approximate amount of the offending substance.

In another case, a bakery was getting its output back from time to time because the bread, cakes and coffee rings had a bad taste. There seemed to be no difference in baking procedure or materials to account for it. It was discovered that the off-flavor developed only on days when the wind blew from a certain direction — that of a nearby chemical plant producing a chlorinated phenol. The testing panel found the same unpleasant odor and flavor in the baked goods as that of the chlorinated phenol. Chemical analysis of the atmosphere in the bakery showed that the maximum concentration of chlorinated phenol was 0.2 parts per million. The same off-odor and -flavor were reproduced in the laboratory by exposure of fresh baked goods to an atmosphere containing 0.2 parts per million of the chlorinated phenol.

In another case, nearly 100 samples of chocolate powder used for making hot cocoa have been studied to determine the cause of flavor deterioration in the packaged product.

After accelerated aging of these samples, the cocoa was sifted and tested by the members of the panel. It was found that the cocoa alone, when aged in glass under the same conditions, deteriorated less than samples which had been in contact

with boxboard. Recommendations were made for improved packaging, based on results of these tests.

Oxidation is Factor

➤ THE "SUNLIGHT" flavor of milk is really a mild rancidity caused by the action of light on butterfat, Dr. George R. Greenbank of the Bureau of Dairy Industry, United States Department of Agriculture, Washington, D. C., told the meeting of the American Chemical Society.

Dr. Greenbank received the $1,000 Borden Award in the Chemistry of Milk at a general assembly of the Society in recognition of his contribution during a quarter century of research, particularly in improving the quality of powdered milk.

Probably all dairy products except evaporated milk develop off flavors by oxidation of fatty constituents, he asserted, pointing out that since $7,000,000,000 worth of milk and dairy products are consumed each year because of their nutritive value and wholesome flavor, investigation of abnormal tastes and their causes is economically significant research.

In his studies on oxidation, Dr. Greenbank reported, he found that light promotes the oxidation of fats and causes specific flavors to develop in milk, sometimes referred to as "sunlight" flavor. The shorter the wavelength of the light, the more rapid the oxidation, he observed.

Even dried skim milk, free of fats, is prone to change flavor through oxidation, he said, explaining that air in the milk is responsible for the "cardboard," or "cappy," taste which develops in milk after storage at near freezing temperatures for a day or two. In the case of fat-free milk, it is the so-called phospholipid compounds which are affected, and if they are oxidized further the flavor disappears.

Several years ago, Dr. Greenbank recalled, he and his associates tried adding lactic acid to milk. Lactic acid is the chemical that gives sour milk its typical taste, but when their acidified milk was dried, the chemists found that it kept longer without spoiling.

This interesting fact meshed neatly with another discovery made later—that carbon dioxide packed with milk powder is a far better preservative than other inert gases, such as nitrogen. It may be, Dr. Greenbank said, that the carbon dioxide owes its effectiveness to the fact that it combines with the small amount of remaining moisture to form an acid. Acid, it is thought, regenerates natural anti-oxidizing chemicals in milk.

Streptomycin Cures Plague in India

➤ PROOF THAT streptomycin cures plague was given recently by General Sir Sahib Singh Sokhey, director of the Haffkine Institute in Bombay. In experimental tests with plague-infected mice, streptomycin treatment resulted in 100% cures.

When 87 human patients with bubonic plague, including 15 in an advanced, usually fatal stage of the disease, were given streptomycin treatment, all but two recovered. The streptomycin was donated by Dr. Robert D. Coghill of Abbott Laboratories, North Chicago, Ill., and the British Medical Research Council.

Dramamine, Sea-Sickness Preventive, Allows Cancer Patients to Stand X-Rays

Radiation Sickness Relieved

➤ DISCOVERY of a new drug to help cancer and leukemia patients undergoing X-ray or radium treatment has been made by three Mayo Clinic doctors.

The drug is dramamine, the air and seasickness remedy and preventive which started out as a drug for hayfever patients.

Many patients who must have X-ray or radium treatment for life-threatening, deep-seated cancers or for leukemia get so sick from the radiation that the treatment which might save them has to be stopped. Vomiting, nausea, loss of appetite, weakness, exhaustion or prostration are the symptoms of the radiation sickness.

Good to excellent relief of these symptoms was obtained in 65 of 82 patients when they were given dramamine before and after the X-ray or radium treatment, the Mayo Clinic group, Drs. John W. Beeler, Jan H. Tillisch and Walter C. Popp, report.

Every one of the patients had previously had marked nausea from the radiation treatment and 53 of them had been vomiting as well. The dramamine was given to them in three doses: one pill half an hour to an hour before the radiation treatment, another an hour and a half after and a third three hours later. In four of the 13 patients who had a poor result from the dramamine, vomiting between doses made them unable to retain and absorb the drug.

In order to rule out any psychologic effect and make sure the good results were due to the drug, 23 patients with radiation sickness were given pills that looked like dramamine and which they thought were dramamine but which actually were not. Only 13% of the patients in this group had good or excellent results, compared to 79% in the group getting dramamine.

Of the 82 patients who got dramamine, 15 complained of feeling drowsy or sleepy and three refused to take the pills after three to four days of continued sleepiness. But several of the patients getting the substitute pill, or placebo, also complained of drowsiness and dizziness.

The striking likeness between the symptoms of air and seasickness or car sickness and radiation sickness is what led the Mayo group to try dramamine. Various other chemicals have been tried to relieve radiation sickness, including B vitamins and antihistamine chemicals. Dramamine is an anti-histamine chemical, although there are other drugs with a more marked anti-histamine effect. In some cases, especially when the X-ray treatment is given over the upper part of the stomach region, a combination of dramamine and injections into the veins of vitamin B-6, or pyridoxine, gave better results, the Mayo doctors report, than either drug alone.

Just how dramamine works as both preventive and remedy for motion sickness is not known. It may have a

specific depressing effect on the vomiting reflex. This would explain its action in both motion and radiation sickness, at least in checking the nausea and vomiting. This does not explain why it relieves other symptoms such as the malaise, prostration and lethargy or lassitude that occur in both radiation and motion sickness. These, however, may be secondary to the stimulation of the vomiting reflex.

Phosphorus Helps Firefly's Light

➤ PHOSPHORUS, the element whose name means "light-bearer," plays a part in producing the firefly's flashing light, Dr. William D. McElroy of the Johns Hopkins University has discovered.

It had previously been known that a special substance in the firefly's light-organ, called luciferin, became luminous on the addition of an enzyme, called luciferase. But this was not a reversible reaction: once the luciferase had "burned out" the luciferin, no further additions would produce any more light.

Dr. McElroy found that the luciferin could be built up again by the addition of a phosphorus-containing organic compound known as adenosine triphosphate, rich in transferable energy. Every addition of this compound to the spent firefly illuminant was signalled by a brilliant flash of light, which was maintained for a considerable time, in proportion to the adenosine triphosphate concentration. This compound therefore seems to be the oil for the firefly's lamp.

Atomic Pile For Unknown Analysis

➤ ATOMIC piles can be used to find out how much of a chemical element is in an unknown material, even when there is only about one part of the element in perhaps a hundred million parts of the material.

This new use was worked out by a pair of scientists at the University of Chicago's Institute for Nuclear Studies and the Argonne National Laboratory.

First pile-measurements were made of two of the rarer elements found in meteorites.

Dr. Harrison Brown and a graduate student, Edward Goldberg, used the Argonne heavy water pile to determine how much of the elements gallium and palladium were present in various iron meteorite samples. These and other studies of the chemical make-up of meteorites may give important clues to the structure of planets, including the earth, and the origin of our solar system.

Both a piece of the material being studied and a known weight of the element being sought are irradiated in the atomic furnace. The activity induced in the known and the unknown samples is then compared, to find out how much of the element there is in the material being analyzed.

Results from these tests of meteorites were so satisfactory that the scientists believe the atomic pile can be an important new tool for finding and measuring tiny amounts of chemical elements in an unknown material.

Quartz Crystals Vibrate, Produce Ultrasonic Waves

Crystals For Ultrasonic Use

From the new book *Ultrasonics*, McGraw-Hill, $5.
(Used by courtesy McGraw Hill Book Co., Inc.)

by BENSON CARLIN

THE MOST POPULAR types of electromechanical converting systems are the piezoelectric and magnetostrictive ones, although there are also two other types, viz., the electromagnetic and electrostatic. These last two types are used in generating acoustic waves in air and are not of much interest in ultrasonics except possibly in sound ranging.

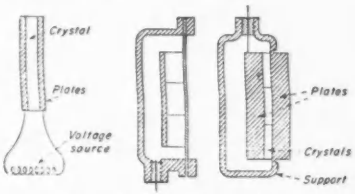
The piezoelectric effect is of greatest importance in certain types of ultrasonic work, although the magnetostrictive is also widely used and will therefore be discussed separately. The former effect occurs in several natural and artificial crystals and is defined as a change in the dimensions when an electric charge is applied to the crystal faces.

Quartz crystals have been widely used for generating ultrasonic vibrations in solids and liquids, since they are media that have a high mechanical impedance. Where the impedance is low, the ratio between the output and the charge applied to the vibrating crystal is too small for effective use.

Especially in ultrasonic work at the higher frequencies, where there may be contact between the transducer and a solid medium or where great power is not important, longitudinally or shear vibrating quartz crystals are still most commonly used.

Frequencies produced by quartz blanks cover a range from a few hundred kilocycles to about 15 mc when vibrating in a fundamental mode and are capable of producing very much higher frequencies when operating at a harmonic.

Professor Langevin was the first to apply the piezoelectric effect to the problem of ultrasonic generation when he was commissioned by the French government during the First World War to find a means of locating enemy submarines, which at the time were attacking French vessels. He found, after considering the problem, that the piezoelectric effect made the quartz crystal useful for this purpose, and his patent[1] discloses the idea of a mosaic of crystal cemented between steel plates and used to generate and receive ultrasonic waves.



From Carlin's *Ultrasonics*.

The quartz crystal has the property of expanding and sending out an ultrasonic wave when a voltage is applied to it, and it can also produce an electrical signal when it is mechanically vibrated. The device was not used during the war of 1914-1918 to any extent, since its development was not

[1] P. Langevin, British Patent 145,691, 1921.

completed soon enough. However, since that time the quartz crystal has become the basis of many underwater detecting and signaling means, of listening systems, and of depth-finding devices. Of course, since the date of Langevin's patent a huge amount of additional experiment has been carried out.

Besides quartz, Rochelle salt* is one of the principal materials used in the generation of ultrasonics, especially in the low-frequency ranges and for use submerged in a liquid, as in submarine signaling.

A. M. Nicolson[2] of the Bell Laboratories did pioneer work with the Rochelle salt crystal at about the same time that Langevin was working. The piezoelectric effect in Rochelle salt is considerably greater than it is in quartz. However, the units are much softer and therefore more subject to breakage and damage than quartz. On the other hand, in submarine work, the transducer is protected by its housing, and Rochelle salt can therefore be used.

During the Second World War several other artificial crystals were developed, mainly for submarine work. These crystals have characteristics especially adapted to such applications.

From every point of view, durability, economy, ease of manufacture, and simplicity, the quartz crystal is the most desirable of all the types of generating units that may be chosen for ultrasonic work. The *X* cut is the most commonly used, since it generates longitudinal, or *L*, waves. For the production of shear waves *Y* cuts are also used, but this type of wave motion will not travel through liquids or gases, in which there is no shear elasticity, and for use with solids they must be coupled to the work by special means. For these reasons *Y*-cut crystals are not widely applied.

Natural quartz is an extremely stable material, both chemically and physically, and very hard. It is usually found in the shape of a prism of six sides, with a pyramid attached to each end. If the points of these pyramids are joined by a line, that line is defined as the optical, or *Z*, *axis*.

The *X* axes are also called the electrical ones and are defined by lines passing through the opposite corners of the crystal. There are therefore three *X* axes to each natural piece of quartz. The *Y* axes are perpendicular to the sides of the figure. There are therefore three of these also. Both of these axes are perpendicular to the *Z*, or optical, axis.

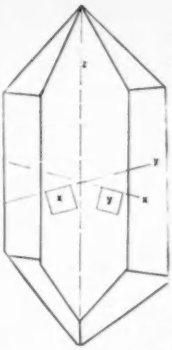
Plates or blanks can be cut to either of these axes (or in many other ways), and in each case they have certain definite characteristics. Blanks can be cut for fundamental vibration up to about 10 to 15 mc. Beyond this range they become so thin that they have a tendency toward mechanical failure. Accordingly, crystals for higher frequencies are cut at a subharmonic.

The crystals must have parallel faces and be polished free of all kinds of chips or cracks; otherwise they will not vibrate freely. Optical emery finish is usually satisfactory for ultrasonic work.

The figure shows the shape of the

* Potassium Sodium Tartrate — EDITOR'S NOTE.

[2] A. M. Nicolson, The Piezoelectric Effect in the Composite Rochelle Salt Crystal, *Proc. Amer. Inst. Elec. Engrs.*, 38, 1315 (1919).



(From Carlin's *Ultrasonics.*)

natural quartz crystal and the orientation of the common ultrasonic cuts.

The fact that certain crystals will develop an electric charge when a mechanical pressure or tension is applied was discovered in 1880 by the Curie brothers. This phenomenon was later named the *piezoelectric effect.*[2] Their experiments showed that there was a direct proportion between the mechanical pressure and the resultant charge. Moreover, the sign of the charge changed when pressure changed to tension or vice versa.

The effect is present in many types of crystals, but it is most useful in quartz and Rochelle salt. However, as mentioned, a number of artificial crystals were developed during the late war, which are mainly designed for submarine signaling and are not suited for the transmission of ultrasonics into solids.

The polar axis of a quartz crystal is the point at which the maximum charge will appear. It is there also called the *piezo axis.* This axis can be identified by rotating the crystal. When the rotation is carried out about an axis perpendicular to the polar axis, the crystal is not symmetrical.

[2] P. Curie and J. Curie, Développement par pression de l' électricité polaire dans les cristaux hémièdres à faces enclinees, *Compt. rend.*, *91*, 383 (1880).

The polar axis is important because the blanks used in ultrasonics are cut at right angles to it to get the maximum effect. Moreover, the crystal differs at the ends of this axis optically, chemically, and physically. Etching produces different patterns, and stresses produce charges of different signs.

When a crystal is cut in the *x* or *y* direction, it has the characteristic that pressure on the *X* axis produces a charge on the crystal surfaces perpendicular to the axis. This is known as the *longitudinal direct effect.* The transverse direct effect will produce the same charges that pressure on the *X* axis would produce but will do it as the result of tension on the *Y* axis.

When tension is changed to pressure or vice versa, the *x* sign of the effect changes but otherwise there is no electrical change. Therefore, if an alternating charge is applied at high frequency to the crystal, and if the crystal is properly designed to oscillate at that frequency, it will follow the applied field. The faces of the crystal will move with respect to each other; and if one face is pressed against the surface of a medium, ultrasonic waves will be produced and enter the medium and then travel through that medium (if, of course, the medium is able to support the propagation of ultrasonics).

It is not theoretically necessary for a crystal to vibrate or oscillate at its resonant frequency. Crystals can be driven at any frequency whatever, provided only that the power applied by the oscillator or generator is great enough. However, the amplitude of crystal oscillation is so much greater

at resonance that crystals are rarely used at any other frequency except when there is some definite reason for doing so. A typical reason would be the necessity for thick plates at comparatively high frequencies in agitation. In such a case a low-frequency plate is driven at a higher harmonic frequency. In a like manner high-frequency crystals can be driven at lower frequencies. This is commonly done in resonance work where a crystal is driven over a range covering a group of frequencies all below its natural or resonant one. In this manner resonances in the medium are made to indicate without being influenced by resonance in the crystal.

Photographic Wash Water Reusable

➤ THE SAME old batch of wash water used in Army field photographic laboratories may be used over and over again by a method of purification developed by the Signal Corps.

In a typical field laboratory approximately 3,000 gallons of fresh water are needed in a 24-hour period. With the new development, a supply of about 10 gallons is sufficient if purified and reused many times. The process is based on ion exchange. It is used by industry to soften water fed to large boilers, and was used by the Navy during the war to produce drinking water from the ocean brine.

In the Signal Corps process, the water, after use in washing photographs, is passed over thousands of tiny particles of synthetic resin. These filter out and recapture silver and other impurities acquired by the water in the washing procedure. The water, stored in a tank located in the mobile laboratory, is pumped to a print washer where it removes hypo from the prints, circulates back to the resins, and is then in condition for reuse.

The synthetic resins used are virtually indestructible and can be rejuvenated by the simple process of immersing them in either battery acid or washing soda, depending upon the particular type of resin.

While this process is suitable to purify water for reuse for washing photographic prints, it cannot be used to purify water for drinking purposes because the resins are ineffective in killing bacteria or lower forms of organisms.

Radioactive Soil Buried After Tests

➤ RADIOACTIVE elements used in fertilizer tests on plants by U.S. Department of Agriculture scientists have necessitated a revolution in handling used soil and its greenhouse containers afterwards. Too "tricky" to be kept for re-use, both soil and containers are deeply buried.

The trickiness does not consist so much in danger to the experimenters (though that might enter the problem, in some cases) as in the fact that some of the stuff remains radioactive for a long time afterwards, and would falsify readings on Geiger counters if it were left lying about.

Because of this once-only use, cheap tin cans coated with enamel have replaced the familiar clay flowerpots and jars.

New Patents Granted
On a Variety of Subjects

Ideas of Interest to Chemists

Copies of complete patent specifications may be obtained from the Commissioner of Patents, Washington 25, D.C. Order by number and enclose 25 cents in cash, money order or Patent Office coupon (not stamps) for each patent ordered.

Analyzer For Gases

➤ QUICK AND accurate analysis of gaseous mixtures can be made in the apparatus on which patent 2,468,261 has been granted to Dr. James Hillier of Cranbury, N.J., research engineer for the Radio Corporation of America. A narrowly focussed electron beam is passed through a sample of the gas in an inverted J-shaped sealed glass vessel. Passed through a powerful magnetic field, the beam is divided and bent before it falls on a recording target; the degree of division and bending tells what gases are present and in what concentrations.

Uranium Compound

➤ URANIUM TETRABROMIDE, a compound of technical importance in the production and manipulation of radioactive materials, is prepared from uranium oxide in a newer, less costly way under the procedure on which patent 2,469,916 has been issued to James M. Carter of Pasadena, Calif., who in turn has assigned it to the Atomic Energy Commission.

The oxide is mixed with sulfur in a flask, and bromine is added from a small reservoir. A temperature of about 170 degrees Centigrade is maintained, and the mixture is kept constantly stirred. After about 15 hours, what remains of bromine and sulfur bromide are driven off by heat, and the remaining sulfur is extracted with carbon tetrachloride. Uranium tetrabromide remains in the flask; it may be further purified by sublimation.

Fluorine Rubber

➤ SYNTHETIC rubbers containing fluorine instead of the more customary chlorine, such as vinyl fluorides, are the subject of patent 2,469,848, taken out by a duPont chemist, L. F. Salisbury. Special element of novelty is the mercury - containing, large - moleculed catalyst used.

Wood Fungicide

➤ FUNGICIDE treatment of wood, in which nickel salts are used instead of their more familiar copper analogs, is covered in patent 2,469,427, obtained by Dr. Roy H. Baechler of the U.S. Forest Products Laboratory at Madison, Wis. Copper-treated wood often remains so hot after burning as to be a fire hazard for a considerable time; this risk is eliminated by the new treatment. Dr. Baechler has dedicated his patent to the free use of the people of the United States.

New Aluminum Process

➤ ANOTHER British invention on which a U.S. patent has been issued is a method for refining aluminum by thermochemical means instead of the

electrolytic method that has dominated the industry since its introduction in this country by Hall a couple of generations ago.

Basis of the new method is the fact that if aluminum ore is heated in intimate contact with either the chloride, bromide or fluoride of aluminum, the metal will be sublimed or evaporated out of the ore, to condense later to a liquid state in a cooler part of the reacting vessel. Preferably, the process is carried out under partial vacuum. Patent 2,470,305, issued on this process to Philipp Gross, is assigned to International Alloys, Ltd., of Slough, England.

Lignite for Smelting Iron

➤ ANOTHER NEWLY patented metallurgical novelty is the use of lignite or other non-coking fuel for reducing iron ore. On this, patent 2,470,106 has been taken out by Vernon F. Parry of Golden, Colo. Raw lignite and briquetted ground ore are charged together into a tower surrounded by a heating chamber. Steam is added to the gas generated from the fuel, forming hydrogen and carbon monoxide, which increase the thermal value of the gas. The molten iron is drawn out of the bottom of the tower.

Oil-Shale Extractor

➤ GETTING LIQUID fuels and lubricating oils out of oil shales without the costly necessity of grinding them to fine powder is the basis of patent 2,471,119, granted to two Standard Oil Development Company engineers, E. B. Peck and D. G. Tomkins. Essential step in the process is the subjection of the coarse-ground shale to the action of hot gases from shale that has previously passed through the same apparatus, thereby crumbling them thermally. Gases driven out are passed through a conventional fractionating tower and condenser.

Coagulated Wool

➤ MAKING WOOL non-shrinking by exposing it to sonic vibrations intense enough to cook an egg, thereby coagulating the wool proteins, is the idea on which patent 2,470,453 has been granted to Peter Alexander of Leicester, England.

Glass for Skis

➤ CINDERELLA'S glass slippers have escaped from the ballroom and got out onto the ski run. Carl L. Wheeler of Albuquerque, N. Mex., bonds a glass-fiber layer to the lower surface of skis, making them very literally "as slick as glass." He was awarded patent 2,470,227.

Mild Treatment for Yeast

➤ GETTING VALUABLE food and medicinal materials out of yeast without drastic chemical treatment is accomplished by a process on which Donald K. Alexander of Dolbeau, Que., has received patent 2,470,967. He mixes his yeast suspension with diatomaceous earth, then filters and dries the mixture, keeping it constantly agitated. The yeast-cell contents are thus released by mainly physical means, and can be washed out with a very mild acid solution.

Silicones De-ice Wings

➤ A NEW EMPLOYMENT is found for members of that extremely versatile new chemical family, the silicones, in patent 2,471,224, granted to Dwight L. Loughborough of Akron, Ohio, assignor to the B. F. Goodrich Com-

pany. This silicone, a flexible, rubbery one, is used in the de-icing boots on the leading edges of airplane wings.

Vitamin Helps Fruit

➤ VITAMIN treatment of peaches and similar fruits prevents the objectionable browning that shortens their marketable life in the process on which patent 2,475,838 was granted to two U. S. Department of Agriculture scientists, Gestur Johnson of Fort Collins, Colo., and Dante G. Guadagni of Albany, Calif. The fruit is immersed for appropriate periods in a solution containing ascorbic acid, sulfur dioxide and common salt. Patent rights are assigned royalty-free to the government.

Purification of Subtilin

➤ SIMILARLY assigned is patent 2,476,085, taken out by a group of five researchers headed by Keene P. Dimick of Redwood City, Calif., on a process for the purification of one of the newer antibiotics, subtilin. Unlike most drugs of its type, which come from molds, subtilin is produced by a bacterial species, Bacillus subtilis. First extraction is made with butanol, then treatment with acidulated water brings out subtilin in a high state of purity, and a precipitation process makes collection possible.

Fruit Pasteurized

➤ STILL ANOTHER government-assigned patent is No. 2,476,251, issued to T. L. Swenson of Berkeley, Calif., on a process for heating fruits in a high-frequency electrostatic field, to pasteurize them throughout and at the same time inactivate certain enzymes which would carry them past the state of desirable ripeness if their action were permitted to continue unchecked.

Tea Concentrate

➤ COFFEE concentrates are familiar market commodities, tea extracts less so. Donald K. Tressler of Westport, Conn., produces a highly concentrated tea essence by steeping the leaves at boiling-water temperature and then condensing the aromatic steam distillate. On this process he has received patent 2,476,072.

Sterol for Vitamin D

➤ A STEROL from which an especially desirable form of vitamin D can be prepared is found in a species of mussel, *Modiolus demissus*. On a process for extracting and preparing this, Hans R. Rosenberg of Wilmington, Del., has taken out patent 2,475,917, which he has assigned to E. I. du Pont de Nemours and Company.

Yellow Phosphorus to Red

➤ A METHOD for converting yellow phosphorus into the more easily and safely handled red form is covered by patent 2,476,335, assigned to the Tennessee Valley Authority by the inventor, John R. Tusson of Princeton, N. J. Red and yellow phosphorus are mechanically kneaded together by rollers as they move through a screw convevor. More yellow phosphorus is introduced in vapor state. Fire is guarded against by maintaining an atmosphere of an inert gas containing no oxygen.

Healing Chlorophyll

➤ CHLOROPHYLL is converted into a compound for which antiseptic and tissue-healing properties are claimed, by substituting a mercury atom for the one magnesium atom in the chlorophyll molecule, in the invention of Holton W. Diamond and Robert A. Smith, both of Dearborn, Mich. Their

patent, No. 2,476,358, is assigned to the Ford Motor Company.

Antiseptic Chewing Gum

➤ A CHEWING GUM having antiseptic properties is the subject of patent 2,476,687, taken out by J. A. Smith of Memphis, Tenn. It contains a reducible silver salt.

Black Stainless Steel

➤ TO MAKE stainless steel a lustrous black instead of its natural dull silver tone, Daniel J. Clini of Springfield, Mass., immerses it in a bath containing hydroxide, permanganate, sulfate and sulfide, and heats to a temperature of 250 degrees Fahrenheit. The patent number is 2,476,700.

Explosive Magnesium Dust

➤ ANY PHOTOGRAPHER who has ever tried to use old-fashioned flashlight powder knows how explosive it can be. This property is used to advantage in a new explosive compound developed by William F. Van Loenen of Los Altos, Calif.

Basis of the explosive is magnesium powder much finer than flashlight powder; it is prepared by quick-chilling of magnesium vapor. The almost impalpably fine grains are then coated with asphalt or other hydrocarbon. Patent 2,477,549, issued on this invention, is assigned to the Permanente Metals Corporation.

Aluminum From Clay

➤ THE OLD PROBLEM of getting aluminum out of common clay, which is aluminum silicate, is tackled anew by Erwin C. Hoeman of Columbus, Ohio, patent 2,476,799. He converts the silicate into a sulfate by treatment with strong sulfuric acid. Subsequently he removes metallic impurities by a further washing with sulfuric acid. The purified aluminum sulfate is subsequently reduced to metallic aluminum by conventional methods.

Fibrous Paper

➤ AN EXCEEDINGLY tough, fibrous paper, suitable for such special purposes as tea bags and mimeograph stencils, is made almost entirely of finely extruded synthetic fibers of such materials as cellulose acetate or nitrate, Vinylite or Aralac, with just a little flax or Manila hemp fiber as binder. On this product Fay H. Osborne of Windsor Locks, Conn., has received patent 2,477,000.

Pierced Diamonds

➤ IMPROVEMENTS in the electrical piercing of commercial diamonds to form fine-wire dyes are embodied in patent 2,476,965, granted to two National Bureau of Standards staff members, W. B. Emerson and I. L. Cooter. The process is carried out in an electrolytic bath. Patent rights are assigned royalty-free to the government.

Lubricants From Coal

➤ ALSO government-assigned is patent 2,476,999, taken out by Milton Orchin of Pittsburgh, on a new method for obtaining lubricants and liquid fuels from coal. The process involves heating under pressure, in the presence of a phenolic or naphthalenic solvent.

Uranium Concentration

➤ A NEW PROCESS for the concentration of uranium out of its ores has been disclosed by the issuance of U. S. patent 2,477,924 to Sherman M. Fried

of Chicago and Norman R. Davidson of Sierra Madre, Calif. They have assigned their patent rights to the government, as represented by the Atomic Energy Commission.

The new process covers just one step in the concentration of uranium oxides, from uranyl uranate (U_3O_8) to uranium trioxide (UO_3). Essentially, it consists in heating the lower oxide in the presence of oxygen under pressure. Extent of conversion and time required vary according to temperatures and pressures employed. Time may be cut to as little as one and one-half or two hours by using pressures of from 60 to 150 atmospheres at a temperature between 700 and 750 degrees Centigrade.

New Color Television

▶ A COLOR TELEVISION system requiring no light filters and hence involving less loss of brightness is the offering of Louis W. Parker of Jackson Heights, N. Y., for patent 2,477,645, which he has assigned to the Federal Telephone and Radio Corporation. He makes the first conversion from radio to light waves in the form of ultraviolet radiation, then scans these rays against the successively presented faces of a polygonal rotating drum. Each of the faces is coated with a phosphor that will fluoresce in a different color when excited by the ultraviolet rays, thus producing the desired polychrome effect in the final viewing.

Static Makes Sprays Stick

▶ INSECTICIDE and fungicide dusts and sprays are made to stick to plants by giving each particle or droplet an electrostatic charge, in the invention of Oleg Yadoff of Versailles, France. The charges are imparted by shooting the spray of dusting material through a nozzle at a velocity greater than that of sound. Such charged particles cling very tightly, the inventor states, and are not readily washed or blown away. Rights in Mr. Yadoff's patent, No. 2,477,947, are assigned to the Electronic Dusting Corporation, of New York.

Zinc Chills Zinc Vapor

▶ SMELTING ZINC presents some difficult technical problems because of the metal's curious reluctance to remain in a molten condition; it tends to pass directly from solid to vapor state, in which it avidly seizes on any stray oxygen, to become an oxide rather than a pure metal. In the setup developed by Augustin L. J. Queneau of Morristown, N. J., patent 2,478,594, the zinc vapor, at temperatures approaching 1,000 degrees Centigrade, is chilled and induced to condense by contact with liquid zinc at some temperature above its freezing-point, 420 degrees Centigrade. Oxidation troubles are abated by conducting the operation in an atmosphere of an inert gas such as nitrogen or carbon monoxide.

Reflector Microscope

▶ THE REFLECTOR principle, long used in the world's great telescopes, is beginning to be applied at the other end of the optical scale, to microscopes. A reflecting instrument of this class is covered by patent 2,478,762, granted to Lyle T. Johnson of La Plata, Md. It can be used with ultraviolet radiation as well as with visible light.

Air Conditioning in Mines

▶ AIR CONDITIONING, now a commonplace in homes, offices, factories and amusement places, is about to descend

to mines, where for generations heat and high humidity have conspired to reduce the productivity and shorten the working lives of some of the world's most highly skilled workmen. U. S. patent 2,479,408 has been issued to Allan S. Richardson of Butte, Mont., on a system for drying and cooling the air in which miners work.

Air within the mine is drawn into a series of ducts and passed over the surface of a cooled, water-absorbing liquid, such as diethylene glycol or a strong solution of calcium chloride. With temperature and relative humidity reduced, it is then delivered as near as possible to the working face. The warmed and water-logged liquid is pumped to the surface, where it is heated to drive out the water, then recooled for return through the circuit.

Liquid Air Replaces Ice

➤ LIQUID AIR, once a curiosity used in scientific "magic" shows, has now become so abundant and cheap as an industrial byproduct that it can compete with ice and mechanical refrigeration. The Shell Development Company is assignee of four patents on its use as a refrigerant, taken out by a group of inventors. Two of these have to do with large-scale uses, as in freight cars, trucks and ships' holds; the other two are on its application to ordinary kitchen-sized refrigerators. Various means are employed to apply its chilling powers; typical is its simple evaporation into the refrigerated space through vents under thermostatic control. The patent numbers are: 2,479,821, to R. K. Deutsch of Chicago, F. A. Larson, Bronxville, N. Y., and V. E. Middlebrock, Tulsa, Okla.; 2,479,840 to A. J. Johnson and T. W. Rosebaugh of Oakland, Calif.; 2,479,866 and 2,479,867 to T. W. Rosebaugh of Oakland

Saves Combustion Products

➤ ONE OF THE end-products of gasoline combustion in engines is water. To salvage at least a part of this on aircraft in flight is the object of patent 2,479,766 taken out by Harry A. Mulvany of Berkeley, Calif. He passes the exhaust through a condenser cooled by the slipstream, afterwards eliminating poisonous byproducts such as lead and ammonia.

New Kind of Brass

➤ LONG PAST are the days when brass could be defined as an alloy of copper and zinc. Other metals now enter in, to improve it for various uses. On one alloy, featuring relatively high manganese content, but also additions of silicon and aluminum, patent 2,479,595 has been given to E. A. Anderson and D. C. Jillson of Palmerton, Pa., assignors to the New Jersey Zinc Company.

Smudge Pot Lighter

➤ CITRUS FRUIT growers, and others who use burning smudge pots to protect crops from untimely freezes, will be saved the hand labor of lighting the pots by an automatic igniter. By an ingenious arrangement, when the temperature in a field is lowered below a selected critical point, a chemical, such as isopropyl alcohol, is brought automatically in contact with a tablet compounded of chromic anhydride, iodine crystals and potassium nitrate. Flaming follows, and the flame lights the oil wick. Sydney R. Crockett, Freeport, N. Y., received patent 2,480,397 for this device, and has assigned it to Cyril Charles Crockett, Glendale, Calif.

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